PB81-182339

Guidelines for the Disposal of PCBs (Polychlorinated Biphenyls) and PCB Items by Thermal Destruction

TRW, Inc.
Redondo Beach, CA

Prepared for

Industrial Environmental Research Lab.
Research Triangle Park, NC

Feb 81

U.S. Department of Commerce
National Technical Information Service
NTIS

PB81-182339

United States
Environmental Protection
Agency

EPA-600/2-81-022
February 1981

EPA

Research and Development

GUIDELINES FOR THE DISPOSAL OF PCBS AND PCB ITEMS BY THERMAL DESTRUCTION

Prepared for

OFFICE OF PESTICIDES AND TOXIC SUBSTANCES
AND
REGIONS 1 - 10

Prepared by

Industrial Environmental Research
Laboratory
Research Triangle Park NC 27711

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/2-81-022

2.

3. RECIPIENT'S ACCESSION NO. PB81 182339

4. TITLE AND SUBTITLE Guidelines for the Disposal of PCBs and PCB Items by Thermal Destruction

5. REPORT DATE February 1981

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S) D. G. Ackerman, L. L. Scinto, P. S. Bakshi, D. L. Anderson, R. G. Delumyea, R. J. Johnson, G. Richard, and A. M. Takata

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

TRW, Inc.
One Space Park
Redondo Beach, California 90278

10. PROGRAM ELEMENT NO. C1YL1B

11. CONTRACT/GRANT NO. 68-02-3174, Task 1

12. SPONSORING AGENCY NAME AND ADDRESS

EPA, Office of Research and Development
Industrial Environmental Research Laboratory
Research Triangle Park, NC 27711

13. TYPE OF REPORT AND PERIOD COVERED Task Final; 10/79-4/80

14. SPONSORING AGENCY CODE EPA/600/13

15. SUPPLEMENTARY NOTES IERL-RTP project officer is David C. Sanchez, Mail Drop 62, 919/541-2547.

16. ABSTRACT The report is a resource and guidelines document to aid EPA Regional Offices in interpreting and applying polychlorinated biphenyl (PCB) regulations to the thermal destruction of PCBs. As background material, the report describes fundamental processes of combustion, thermal destruction systems, sampling and analysis methodology, and flame chemistry relative to PCB incineration. Administrative considerations, including public involvement, are discussed. Detailed guidelines on the evaluation of Annex I incinerators, high efficiency boilers, and the several stages of the approval process are presented and discussed.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution Chlorine Aromatic Compounds Biphenyl Incinerators Boilers Combustion Pyrolysis Sampling Analyzing	Pollution Control Stationary Sources Polychlorinated Biphenyls Flame Chemistry	13B 07C 13A 21B 07D 14B

18. DISTRIBUTION STATEMENT Release to Public

19. SECURITY CLASS *(This Report)* Unclassified

20. SECURITY CLASS *(This page)* Unclassified

21. NO. OF PAGES 319

22. PRICE

EPA Form 2220-1 (9-73)

EPA-600/2-81-022
February 1981

GUIDELINES FOR THE DISPOSAL OF PCBs AND PCB ITEMS BY THERMAL DESTRUCTION

by

D.G. Ackerman, L.L. Scinto, P.S. Bakshi, R.G. Delumyea,
R.J. Johnson, G. Richard, and A.M. Takata

TRW, Inc., Environmental Engineering Division
One Space Park
Redondo Beach, CA 90278

Contract No. 68-02-3174, Work Assignment No. 1

EPA Program Element No. C1YL1B

Task Officer: David C. Sanchez

Industrial Environmental Research Laboratory
Office of Environmental Engineering and Technology
Research Triangle Park, NC 27711

Prepared for:

U.S. Environmental Protection Agency
Office of Pesticides and Toxic Substances
and Regions I Through X
Washington, DC 20460

DISCLAIMER

This report has been reviewed by the Industrial Environmental Research Laboratory, the Office of Toxic Substances and Regional Offices of the Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ABSTRACT

This report is a resource and guidelines document intended to aid U.S. Environmental Protection Agency Regional Offices in interpreting and applying the PCB Disposal Regulations to thermal destruction of PCBs.

As background material, this document describes fundamental processes of combustion, thermal destruction systems, sampling and analysis methodology, and flame chemistry relative to PCB incineration. Administrative considerations, including public involvement, are discussed. Detailed guidelines on evaluation of Annex I incinerators, high efficiency boilers, and the several stages of the approval process are presented and discussed.

This report was submitted in fulfillment of Contract No. 68-02-3174, Work Assignment No. 1, by TRW, Inc., Environmental Engineering Division, under sponsorship of the U.S. Environmental Protection Agency. This report covers the period 12 October 1979 to 12 April 1980, and work was completed as of 12 April 1980.

CONTENTS

Page

Abstract. iv
Figures vii
Tables. viii

1. Introduction. 1
    1.1 Background 1
    1.2 The Problem 1
    1.3 Purpose. 6
    1.4 Scope. 7

2. Thermal Destruction Technology. 9
    2.1 Combustion Theory. 9
        2.1.1 Combustion of Liquids 10
        2.1.2 Combustion of Solids. 13
    2.2 Thermal Destruction Systems. 14
        2.2.1 Incineration Systems. 15
        2.2.2 High Efficiency Boilers 48
        2.2.3 Summary 54
    2.3 Sampling and Analysis Methodologies for PCBs 54
        2.3.1 Sampling Methodologies. 56
        2.3.2 Analytical Methodologies. 71
    2.4 Stack Monitoring Instrumentation 83
        2.4.1 Oxygen Monitors 83
        2.4.2 Carbon Monoxide/Carbon Dioxide Monitors 85
        2.4.3 NO, NO_2 Monitors. 86
        2.4.4 Use of Monitoring Equipment 86
    2.5 Combustion of PCBs 87
        2.5.1 Fuel Characteristics. 87
        2.5.2 Combustion Process Characteristics. 88
        2.5.3 Formation Mechanisms. 91
        2.5.4 Thermochemical Equilibrium Analysis 97
    2.6 Other Pertinent Literature 102
    2.7 Summary. 103

3. Administrative Requirements 105
    3.1 Federal Rules and Regulations. 105
    3.2 State and Local Rules and Regulations. 108
    3.3 Spill Control and Reporting Requirements 108
    3.4 Public Notification and Participation. 109

4. Evaluation of Annex I Incinerators 111

CONTENTS (Continued)

Page

4.1 Evaluation of Initial Report. 115
  4.1.1 Incinerator System Design. 118
  4.1.2 Operational Data Capability. 159
  4.1.3 Effluent Monitoring Capability 159
  4.1.4 Sampling Locations 164
  4.1.5 Waste Characterization and Feed Rate 166
  4.1.6 Storage Capability 167
  4.1.7 Site Specific Concerns 170
4.2 Evaluation of Trial Burn Plan 175
  4.2.1 Operational Data 178
  4.2.2 Monitoring, Sampling, and Analysis 179
4.3 Evaluation of Trial Burn. 186
  4.3.1 Completeness of Data 188
  4.3.2 Data Reduction 188
  4.3.3 Data Assessment. 191
4.4 Criteria for Incinerator Permit Approval. 196
  4.4.1 Design and Operational Criteria. 196
  4.4.2 Monitoring and Record Keeping Criteria . . . 199
  4.4.3 Sampling and Analysis. 200
  4.4.4 Waste Composition. 201
  4.4.5 Compliance Criteria. 201
  4.4.6 Waiver Criteria. 202
5. Evaluation of High Efficiency Boilers. 203
  5.1 Evaluation of Notification Information. 203
    5.1.1 Boiler Design and Operation Evaluation . . . 205
    5.1.2 Operational Data Capability. 210
    5.1.3 Waste Characterization and Feed Rate 211
    5.1.4 Effluent Monitoring. 212
    5.1.5 Sampling Locations 212
    5.1.6 Storage Capabilities 213
    5.1.7 Site Specific Concerns 213
  5.2 Evaluation of Trial Burn Plan 214
    5.2.1 Operational Data 215
    5.2.2 Monitoring, Sampling and Analysis. 216
  5.3 Evaluation of Trial Burn Data 218
    5.3.1 Completeness of Data 218
    5.3.2 Data Reduction 218
    5.3.3 Data Assessment. 219
  5.4 Criteria for Approval of Boilers for PCB Destruction 220
    5.4.1 Design and Operational Criteria. 223
    5.4.2 Monitoring and Recording Criteria. 223

CONTENTS (Continued)

Page

5.4.3 Sampling and Analysis 224
5.4.4 Compliance Criteria 224

References 226

Appendices

A. PCB Regulations 232 231
B. Environmental Assessment 289 291
C. Sample Calculations 302 306

FIGURES

Number		Page
1	Disposal requirements for PCBs and PCB Items.	8
2	Schematic of Rollins Environmental Services rotary kiln incinerator	16
3	Typical vertically fired liquid waste incinerator . . .	27
4	Horizontally fired liquid waste incineration system . .	29
5	Multiple hearth incineration system	33
6	Fluidized bed facility schematic.	37
7	Retort multiple-chamber incinerator	40
8	In-line multiple-chamber incinerator.	40
9	Schematic diagram of a catalytic combustor.	42
10	Schematic diagram of a pyrolysis system	43
11	Atomic International Div. molten salt reactor - process flow and sampling schematic	46
12	Pulverized coal firing methods.	53
13	Cyclone firing of crushed coal.	53
14	Schematic of EPA Method 5 train	58
15	SASS train schematic.	59
16	Schematic of modified Method 5 stack sampling train . .	62
17	Preferred PCB sampling train configuration.	64
18	Assembled sampler and shelter with exploded view of the filter holder	69
19	Flowchart of Annex I incinerator approval process . . .	112
20	Examples of wet scrubber types for emission control . .	139
21	Overall penetration versus cut to mean particle diameter ratio	145
22	PCB incineration waste disposal	151

TABLES

Number		Page
1	Operational Data from PCB Tests at Rollins Environmental Services	20
2	Operational Data from PCB Tests at ENSCO	24
3	Results of Incineration Tests of Ethylene and Hexachlorocyclopentadiene Wastes at the Marquardt Company	31
4	Results of Several Incineration Tests of Organochlorine Wastes Onboard the M/T Vulcanus	31
5	Incineration System Summary	47
6	Summary of PCB Thermal Destruction Tests	55
7	CO, CO_2, O_2 Monitoring Instrumentation	84
8	Percent of PCBs Remaining After Exposure at Different Temperatures	89
9	Percent PCBs Remaining After Treatment at 704°C	90
10	Theoretical Combustion Efficiencies and Equilibrium Concentrations of Major Species from Combustion of Two PCB Wastes	98
11	Pyrolysis of Chlorinated Hydrocarbons: Equilibrium Product Distribution as a Function of Temperature	100
12	Pyrolysis of Highly Chorinated Hydrocarbons: Equilibrium Product Distribution as a Function of Temperature	101
13	Federal Laws/Regulations Pertaining to PCBs	107
14	Checklist for Evaluation of Initial Report	117
15	Theoretical Oxygen Requirements and Product Gas Yields for Complete Combustion	125
16	Configurations of Selected Gas Cleaning Devices Applicable to PCB Incineration Facilities	138
17	Packing Depth Required to Achieve Specified Removal Efficiency	142
18	Murphree Vapor Phase Efficiency for Plate Towers	143
19	Typical L/G Ratios	149
20	Partial List of Liquid Samplers	163
21	Partial List of Flow Rate Measurement Instruments	167
22	Checklist for Evaluating a Trial Burn Plan	176
23	Suggested PCB Trial Burn Plan Outline	177
24	Types of Data from Trial Burn	189
25	Checklist of Trial Burn Results	195

TABLES (Continued)

Number		Page
26	Requirements for Approval to Incinerate Liquid PCBs. . . .	197
27	Requirements to Incinerate Non-Liquid PCBs	198
28	Information for High Efficiency Boilers.	204
29	Recommended Types of Data from Trial Burn in a High Efficiency Boiler.	219
30	Requirements for Burning PCB-Contaminated Dielectric Fluids in High Efficiency Boilers.	221
31	Requirements for Burning PCB-Contaminated Non-Mineral Oil Dielectric Fluids in High Efficiency Boilers	222

1. INTRODUCTION

1. BACKGROUND

Polychlorinated biphenyls (PCBs) are derivatives of the compound biphenyl in which from one to ten of the hydrogen atoms have been replaced with chlorine atoms. PCBs synthesized for commercial use are mixtures of isomers. PCBs are not naturally occurring compounds.

PCBs have extremely high thermal and chemical stability. They are of low volatility (decreases with increasing chlorine content), are relatively nonflammable, and have excellent electrical insulating characteristics. Commercial mixtures are liquids at room temperature. They are insoluble in water, have a low degree of hygroscopicity, and are soluble in most common organic solvents.

There are 209 possible PCB isomers, ranging from three monochloro isomers to one decachloro isomer. The commercial mixtures are very complex, each containing many isomers. Sissons and Welti (1) identified 69 isomers in Aroclor 1254, a commercial mixture produced by Monsanto. Aroclor is a trademark of Monsanto, the principal U.S. manufacturer of PCBs, for a series of PCB mixtures. The digits "12" refer to biphenyl as the parent compound. The digits "54" indicate that the chlorine content of Aroclor 1254 is approximately 54% by weight. From 1971 through 1974, Monsanto produced Aroclor 1016 (an exception to this nomenclature) which was similar to Aroclor 1242 but greatly reduced amounts of penta-, hexa-, and hepta-chloro isomers. Other tradenames for PCBs or PCB fluids are: Chlorextol (Allis-Chalmers), Clophen (Farbenfabriken Bayer), Dykanol (Federal Pacific Electric Co.), Fenclor (Caffaro,S.P.A.), Inerteen (Westinghouse), Kanechlor (Kanegafuchi Chemical Industry Co.), Noflamol (Wagner Electric Corp.), Phenoclor (Prodlec), Pyralene (Prodlec), Pyranol (General Electric), and Santotherm (Mitsubishi-Monsanto).

1.2 THE PROBLEM

The excellent stability characteristics of PCBs made them highly useful in numerous commercial applications: particularly dielectric fluids in capacitors and transformers, but also in heat transfer and hydraulic systems, pigments, plasticizers, carbonless copying paper, electromagnets, components in cutting oils, and others. Their wide use coupled with a lack of recognition of their hazards has led to PCBs being ubiquitously distributed worldwide in virtually all compartments of the environment (2). Highest concentrations are found in industrialized urban areas; but PCBs are found in air, water, soils, and marine samples in remote, unindustrialized areas. Experimental evidence, summarized in Reference 2, indicates that atmospheric transport is the major means by which PCBs have been so widely dispersed.

Although PCBs have low acute toxicities, other adverse effects have been found in humans, laboratory animals, and other organisms (3). A summary of toxicological and epidemiological data on the effects of PCBs, adapted from Reference 3, is given below. More detailed discussions are given in References 2 and 3. PCBs appear to cause tumors in laboratory animals. There are limited human epidemiological data, but excess carcinogenic effects have been observed in several large groups of people exposed to PCBs. Several studies in animals have shown that PCBs cause fetal resorption, birth defects, and high offspring mortality rates at levels of 1-5 mg/kg body weight. There is evidence that PCBs produce immunosuppressive effects in laboratory animals. PCBs have been observed to cause liver damage. PCBs have caused chloracne in human workers occupationally exposed to air levels as low as 0.1 mg/m^3.

Adverse effects observed in laboratory tests also occur in wild animals. PCBs are known to bioaccumulate and to biomagnify. Effects noted in mink fed PCB contaminated fish include reproductive failure, reduced weight gain, increased mortality, and enlargement of liver, kidneys, and heart.

PCB mixtures are extremely toxic to several species of aquatic invertebrates and fish. Aroclor 1254 is toxic to several shrimp species at levels of about 1 ppb. Increased mortality of sheepshead minnows was observed in water containing 0.16 ppb of Aroclor 1254. Concentrations of Aroclor 1242, 1016, and 1254 as low as 0.1 ppb have been demonstrated to depress photosynthetic activity in phytoplankton.

The principal sources (2,3) on health effects of PCBs used in this report indicate that there is very little information on the relative adverse effects (toxicity, oncogenicity, mutogenicity, etc.) of individual isomers or mixtures. It might be argued that the more highly chlorinated isomers or mixtures are more harmful, if only by virtue of the facts that they are less readily metabolized and eliminated than the less highly chlorinated species. However, EPA has not established standards for the different mixtures because all PCB mixtures: 1) can induce toxic effects at low levels, 2) include highly persistent components, and 3) include components that are subject to significant uptake and storage.

The realization of the widespread distribution of PCBs in the environment and growing knowledge of their hazards led Monsanto in 1972 voluntarily to restrict sales of PCBs to the manufacture of electrical transformers and capacitors. Monsanto ceased all production in 1977.

A few data points serve to illustrate the magnitude of the environmental contamination problem. It has been estimated (2) that over 400,000 metric tons (mt) (900 million pounds) of PCBs were sold domestically in the U.S. during the period 1957-1974. Nisbet and Sarofim (4) have estimated that cumulative sales of PCBs in North America from 1930 through 1970 amounted to 450,000 mt (1 billion pounds). Data from Reference 2 indicate that domestic sales from 1971 through 1974 were 60,000 metric tons (133 million pounds). Total domestic sales may thus be estimated at 510,000 metric tons (1.1 billion pounds). Nisbet and Sarofim (4) also estimated that during the period 1930 through 1970 cumulative losses of PCBs to the environment amounted to 354,000 metric tons (770 million pounds) distributed as follows:

- Air - 27,000 metric tons
- Fresh and coastal water - 54,000 metric tons
- Dumps and landfills - 270,000 metric tons

EPA has estimated (5) that up to and including 1975, between 136,000 and 181,000 metric tons (300 to 400 million pounds) of PCBs had entered the environment.

Growing evidence of the problem of PCB contamination led in 1976 to the inclusion of Section 6(e) in the Toxic Substances Control Act (TSCA). Section 6(e) of TSCA required EPA to regulate the marking and disposal of PCBs already in use. It also provided for a ban on the manufacture and use of PCBs in other than a totally enclosed manner by 1 January 1978, a complete ban on manufacture by 2 July 1979, and a complete ban on distribution in commerce and processing by 1 July 1979. The latter bans include activities conducted in a totally enclosed manner. EPA was, however, authorized to grant exceptions to the ban rules under certain conditions. Regulatory implementation of Section 6(e) is summarized in (3).

On 31 May 1979, EPA promulgated the final rule ("PCB Regulations") under the authority of Section 6(e) of TSCA: Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions (40 CFR 761). This rule: 1) prohibits all manufacturing of PCBs after 2 July 1979; 2) prohibits processing, distribution in commerce, and use of PCBs except in a totally enclosed manner after 1 July 1979; and 3) authorizes certain exemptions. The PCB Regulations do not require removal of PCBs and PCB Items from service and disposal earlier than would normally be required. But, when PCBs and PCB Items are removed from service, disposal must be in accordance with the PCB Regulations. The PCB Regulations generally apply to any substance, mixture, or item containing greater than 50 ppm PCBs.

Regulatory actions by EPA and other Federal agencies apply to PCB disposal. In particular, final and proposed regulations (43 FR 58946) pursuant to the Resource Conservation and Recovery Act (RCRA) address facilities which dispose of hazardous wastes. EPA is currently considering strategies for integrating RCRA standards and TSCA rules for disposing of PCBs. In its Phase I RCRA regulations, EPA has announced that the PCB disposal regulations will be incorporated into the Phase II RCRA regulations (45 FR 33173).

EPA has regulatory authority governing PCB disposal activity under other legislative acts. The Clean Water Act (CWA) and the Marine Protection, Research, and Sanctuaries Act (MPRSA) are used to regulate low concentrations of PCBs entering the environment. Under CWA, EPA can control PCB releases through the National Pollution Discharge Elimination System (NPDES) (Section

402), through dredging permits (Section 404), and through toxic effluent standards and prohibitions (Section 307(a)). CWA also required the President of the U.S. to prepare the National Oil and Hazardous Substances Pollution Contingency Plan. This responsibility was delegated to EPA. The final plan has just been issued (40 CFR 1510, 45 FR 17831). The plan covers spill prevention and control procedures.

The Occupational Safety and Health Administration (OSHA) was established by the Occupational Safety and Health Act. Among other powers, OSHA was authorized to set standards for occupational exposure to chemicals. OSHA has set standards for occupational exposure to PCBs (6):

- Chlorodiphenyl (42% chlorine) - TWA of 1 mg/m^3 and STEL of 2 mg/m^3.
- Chlorodiphenyl (54% chlorine) - TWA of 0.5 mg/m^3 and STEL of 1 mg/m^3.

The TWA (Time Weighted Average) is a concentration to which a worker can be exposed for 8-hour days and 40-hour weeks indefinitely without adverse effects. The STEL (Short Term Exposure Limit) is a level to which a worker may not be exposed for more than 15 minutes without suffering adverse effects.

Large amounts of PCBs are in service which will eventually be subject to or are currently awaiting disposal. No definitive estimate of the total amount of PCBs in service has been found. The Versar data (3) are for 1975, and it can be estimated from those data that 143,000 metric tons of PCBs in 1975 were subject to the PCB Regulations. In the Preamble to the PCB Regulations, EPA estimates (44 FR 31516) that lowering the PCB concentration cutoff from 500 ppm to 50 ppm will result in the control of an additional 454 metric tons (1 million pounds). In addition, EPA estimated that the lower cutoff would result in the control of from 45 to 227 metric tons (100,000 to 500,000 pounds) of new PCBs per year (estimated from manufacturing exemption petitions.) Allen (6) gave an estimate of from 136,000 to 1,364,000 metric tons of liquid PCBs (30 million to 3 billion pounds).

An estimate of the total amount of PCBs subject to eventual disposal is given below. Nesbit and Sarofim (4) estimated that from 1930 through 1970 450,000 metric tons of PCBs had been sold domestically and that an estimated 354,000 metric tons had been released to the environment. Thus, as of the end of 1970, some 96,000 metric tons are estimated to have been in service. Data from Reference 2 showed that from 1971 through 1974 60,000 metric tons of PCBs were sold domestically. Assuming no loss of this latter production (note that in 1972 Monsanto restricted PCB sales to long-lived capacitor and transformer uses), it might be estimated that 156,000 (96,000 plus 60,000) metric tons of PCBs might still be in service. Data taken from an Electric Power Research Institute (EPRI) report, Table 1-1 of Reference 8 indicate that a minimum of 121,400 metric tons of PCBs in utility capacitors exists for eventual disposal over a 40-year period.

The Electric Power Research Institute concludes (8) that there will be a shortfall of utility waste PCB disposal capacity (landfill and incinerator) in most EPA Regions after 1 January 1980. While utilities apparently have the majority of PCB production still in service, there are numerous other commercial and industrial sectors also having PCBs still in service. Thus, there is a disposal problem, and this resource document was prepared, in part, to help ameliorate this disposal problem by aiding the approval process for thermal destruction of PCBs and PCB Items.

1.3 PURPOSE

This report is a resource and guidelines document. It is intended to aid EPA Regional Offices in evaluating facilities which apply for approval for thermal destruction of PCBs. To achieve this purpose, this report provides guidance in:

- Interpreting those portions of the regulations governing thermal destruction (Subpart B for high efficiency boilers and Subpart E for incinerators)
- Establishing criteria for evaluating the consistency of disposal operations with the regulations
- Evaluating for incinerators and high efficiency boilers: Initial Reports, Notifications, Trial Burn plans, Trial Burn data, and Approvals and compliance for thermal destruction of PCBs
- Facilitating coordinated and comprehensive control Agency review of PCB disposal operations

In providing support to EPA Regional Offices, this resource document provides information in the following general areas:

- Description of fundamental combustion processes as they relate to incineration efficiency
- Description and evaluation of thermal destruction technologies that could be used for disposal of PCBs and PCB Items
- Descriptions of thermal destruction tests on PCBs and other relevant materials
- Description and evaluation of monitoring, sampling, and analysis methods used for PCBs

1.4 SCOPE

The PCB Regulations (40 CFR 761) provide four general methods for disposal of PCBs and PCB Items. These methods are:

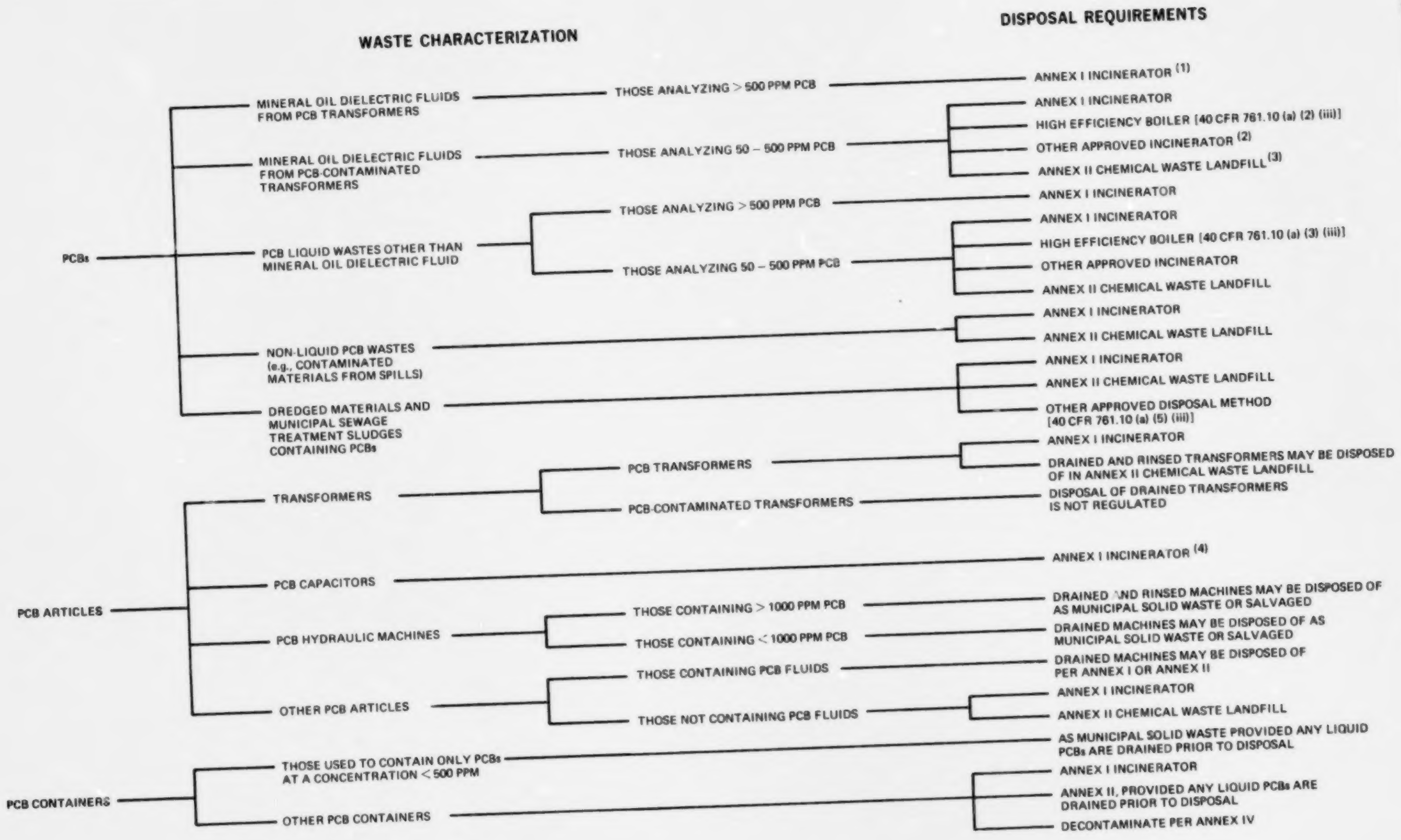
- Incineration in Annex I incinerators
- Incineration in high efficiency boilers
- Disposal in Annex II chemical waste landfills
- Disposal as municipal solid waste

Figure 1 illustrates disposal requirements for PCBs and PCB Items.

This guidelines document applies solely to disposal by thermal destruction in Annex I incinerators and high efficiency boilers. Disposal in Annex II chemical waste landfills or as municipal solid waste is not covered. Nonthermal destruction methods (e.g., chlorinolysis or microwave degradation) are not covered. Sufficient discussion is provided so that capabilities of new or still-developing thermal destruction technologies can be evaluated as disposal methods.

Certain aspects of the PCB Regulations are unclear. Where there are ambiguities, this document provides guidelines and recommendations for clarification.

Chapter 2 of this report describes thermal destruction technology: sampling, analysis, and monitoring techniques and the combustion of PCBs. Chapter 3 describes administrative requirements, a method for determining State and local requirements, and a methodology for involving the public in the process for PCB disposal. Chapter 4 presents guidelines for evaluating Annex I incinerators. Chapter 5 presents guidelines for evaluating high efficiency boilers.


WASTE CHARACTERIZATION
DISPOSAL REQUIREMENTS
PCBs
MINERAL OIL DIELECTRIC FLUIDS FROM PCB TRANSFORMERS
THOSE ANALYZING > 500 PPM PCB
ANNEX I INCINERATOR (1)
MINERAL OIL DIELECTRIC FLUIDS FROM PCB-CONTAMINATED TRANSFORMERS
THOSE ANALYZING 50 – 500 PPM PCB
ANNEX I INCINERATOR
HIGH EFFICIENCY BOILER [40 CFR 761.10 (a) (2) (iii)]
OTHER APPROVED INCINERATOR (2)
ANNEX II CHEMICAL WASTE LANDFILL (3)
PCB LIQUID WASTES OTHER THAN MINERAL OIL DIELECTRIC FLUID
THOSE ANALYZING > 500 PPM PCB
ANNEX I INCINERATOR
THOSE ANALYZING 50 – 500 PPM PCB
ANNEX I INCINERATOR
HIGH EFFICIENCY BOILER [40 CFR 761.10 (a) (3) (iii)]
OTHER APPROVED INCINERATOR
ANNEX II CHEMICAL WASTE LANDFILL
NON-LIQUID PCB WASTES (e.g., CONTAMINATED MATERIALS FROM SPILLS)
ANNEX I INCINERATOR
ANNEX II CHEMICAL WASTE LANDFILL
DREDGED MATERIALS AND MUNICIPAL SEWAGE TREATMENT SLUDGES CONTAINING PCBs
ANNEX I INCINERATOR
ANNEX II CHEMICAL WASTE LANDFILL
OTHER APPROVED DISPOSAL METHOD [40 CFR 761.10 (a) (5) (iii)]
PCB ARTICLES
TRANSFORMERS
PCB TRANSFORMERS
ANNEX I INCINERATOR
DRAINED AND RINSED TRANSFORMERS MAY BE DISPOSED OF IN ANNEX II CHEMICAL WASTE LANDFILL
PCB-CONTAMINATED TRANSFORMERS
DISPOSAL OF DRAINED TRANSFORMERS IS NOT REGULATED
PCB CAPACITORS
ANNEX I INCINERATOR (4)
PCB HYDRAULIC MACHINES
THOSE CONTAINING > 1000 PPM PCB
DRAINED AND RINSED MACHINES MAY BE DISPOSED OF AS MUNICIPAL SOLID WASTE OR SALVAGED
THOSE CONTAINING < 1000 PPM PCB
DRAINED MACHINES MAY BE DISPOSED OF AS MUNICIPAL SOLID WASTE OR SALVAGED
OTHER PCB ARTICLES
THOSE CONTAINING PCB FLUIDS
DRAINED MACHINES MAY BE DISPOSED OF PER ANNEX I OR ANNEX II
THOSE NOT CONTAINING PCB FLUIDS
ANNEX I INCINERATOR
ANNEX II CHEMICAL WASTE LANDFILL
PCB CONTAINERS
THOSE USED TO CONTAIN ONLY PCBs AT A CONCENTRATION < 500 PPM
AS MUNICIPAL SOLID WASTE PROVIDED ANY LIQUID PCBs ARE DRAINED PRIOR TO DISPOSAL
OTHER PCB CONTAINERS
ANNEX I INCINERATOR
ANNEX II, PROVIDED ANY LIQUID PCBs ARE DRAINED PRIOR TO DISPOSAL
DECONTAMINATE PER ANNEX IV

(1) ANNEX I INCINERATOR IS DEFINED AT 40 CFR 761.40.

(2) REQUIREMENTS FOR OTHER APPROVED INCINERATORS ARE DEFINED AT 40 CFR 761.10 (e).

(3) ANNEX II CHEMICAL WASTE LANDFILLS ARE DESCRIBED AT 40 CFR 176.41. ANNEX II DISPOSAL IS PERMITTED IF THE PCB WASTE ANALYZES LESS THAN 500 PPM PBC AND IS NOT IGNITABLE AS PER 40 CFR PART 761.41 (b) (8) (iii).

(4) DISPOSAL OF CONTAINERIZED CAPACITORS IN ANNEX II LANDFILLS IS PERMITTED UNTIL MARCH 1, 1981. THEREAFTER, ONLY ANNEX I INCINERATION IS PERMITTED.

Figure 1. Disposal requirements for PCBs and PCB Items.

2. THERMAL DESTRUCTION TECHNOLOGY

This Chapter presents results of a review of the literature pertinent to thermal destruction of PCBs in chemical waste and other types of incinerators and high efficiency boilers. Section 2.1 summarizes the important aspects of combustion theory which govern the efficiency of thermal destruction. Section 2.2 describes thermal destruction systems for waste incineration, including sizes, controls, operational characteristics, and previous testing programs. Section 2.3 describes sampling methodologies (stack, ambient air, liquid, solid, and work space) used in previous PCB incineration tests. Section 2.3 also describes analytical methodologies used for PCB determinations. Section 2.4 describes monitoring instrumentation that could be used during PCB incineration. Section 2.5 presents a brief discussion of fundamentals of combustion processes, flame chemistry, formation mechanisms, and thermochemical equilibrium analyses as they specifically relate to thermal destruction of PCBs. Section 2.6 presents a brief description of other pertinent literature.

2.1 COMBUSTION THEORY

The fundamentals of combustion theory are discussed in this section to provide the background for evaluations of specific thermal destruction systems. This presentation is adapted from References 8-10 except as noted.

The physical form of the waste, i.e., liquid or solid, is the most important factor influencing the mechanisms of combustion reactions. Therefore, this section discusses combustion of liquids and solids separately. For either physical form, five parameters determine the efficiency of combustion: physical/chemical properties, combustion air, temperature, residence time, and mixing. Each of these parameters is discussed below as it affects the combustion process, and each must be evaluated for specific systems proposed for thermal destruction of PCBs. Guidelines for such evaluations are presented in Sections 4 and 5 for Annex I incinerators and high efficiency boilers, respectively.

2.1.1 Combustion of Liquids

2.1.1.1 Physical/Chemical Properties--

The physical properties of a liquid which are most important in assessing its combustion characteristics are the kinematic viscosity and the size and concentration of suspended solids in the liquid. Since a liquid must be converted to a gas before combustion reactions occur, vaporization of the liquid must be rapid if high combustion efficiency is to be maintained. Vaporization in the combustion chamber requires heat transfer from the hot combustion gases to the liquid, and heat transfer is enhanced if the exposed surface of the liquid is increased. For this reason, liquid surface area is increased by atomizing the liquid into small droplets at the point of air/fuel mixing by burners. Here, the kinematic viscosity of the fluid comes into play, because atomization is better for low viscosity fluids than for high viscosity fluids. Solids in the fuel can impair atomization and cause further problems by plugging, erosion, or buildup in the burners. Operation of a burner with a fuel which is incompatible because of viscosity or solids concentration can result in emission of smoke and unburned particles. Guidelines for evaluating fuel/burner compatibility are presented in Section 4.1.1.1.

The most important chemical properties of a fuel to be considered in assessing its combustion characteristics are elemental composition, moisture, and heating value. Carbon dioxide, and water vapor are the normal products obtained from complete combustion of hydrocarbons in air. But wastes may contain other constituents which give rise to other species. The presence of these species in combustion product gases must be considered, as they may affect air emissions and materials of construction in process equipment. In particular, sulfur in fuels will be released as sulfur dioxide and chlorine as hydrogen chloride. For wastes with a high chlorine content, free chlorine can be formed on combustion unless sufficient hydrogen is supplied by the fuel or by steam injection. Free chlorine is not as easily scrubbed from combustion product gases as HCl and can pose serious emission problems.

All organic compounds have a finite heat content, the quantity of heat released upon combustion. Knowledge of the heat content is important in designing and operating an incineration system and in determining the need for auxiliary fuel.

As a rule of thumb, a minimum heat content of 4400 to 5540 kcal/kg (8,000 to 10,000 Btu/lb) is necessary to sustain combustion. However, some materials with heat contents above 5540 kcal/kg will not sustain combustion without auxiliary fuel, while some materials with heat contents as low as 2490 kcal/kg (4,500 Btu/lb) have been burned without auxiliary fuel. The heat value of a waste decreases as the moisture and/or chlorine content increases. When specifying heat content, the basis (wet or dry, gross or net) must be clearly stated so that an energy balance around the combustion chamber can be properly calculated.

2.1.1.2 Combustion Air--

An adequate supply of combustion air is essential for good thermal destruction. The fuel/waste composition fixes the stoichiometric or theoretical air requirement for a given liquid. However, since perfect mixing is never achieved in practice, excess air must be supplied to ensure adequate contact between fuel and air. Excess air acts as a diluent, reducing the combustion temperature from the theoretical maximum (adiabatic) flame temperature and increasing the mass flow rate of combustion gases. Thus, the selection of the amount of excess air to use must be based on the degree of mixing achieved in the combustion chamber, the desired combustion temperature, and the allowable flow rate of combustion product gases.

2.1.1.3 Temperature--

The major considerations related to combustion temperature are that the temperature is high enough to provide complete combustion but low enough to prevent damage to the combustion chamber. Complete combustion requires a temperature and a heat release rate in the combustion chamber that is high enough to raise the temperature of the incoming fuel above its ignition temperature. In evaluating whether the temperature is high enough, one must consider the effect of temperature on heat transfer to the atomized fuel, mass transfer of the liquid fuel into the gas stream, and oxidation of the mixed gases by air. Heat transfer, mass transfer, and reaction rates all increase with temperature. Thus, for a given residence time and mixing regime, higher temperatures lead to more complete combustion. This points out the close relationship among the "three T's" of combustion: temperature, time, and turbulence.

The current state-of-the-art in combustion modeling does not allow prediction of destruction efficiency for a particular waste from inputs of temperature, time, and turbulence. For now, experience is the best guide to determining what conditions are adequate for thermal destruction of a particular waste. This subject is discussed in Section 2.2, which also discusses normal maximum limits for combustion temperature for various types of systems.

2.1.1.4 Residence Time--

Residence time (dwell time) is the length of time that a molecule of the fuel is exposed to the high temperatures produced in the combustion chamber. The residence time required for a given degree of thermal destruction increases as combustion temperature decreases, all other factors being equal. Not all molecules reside in the combustion chamber for the same length of time. Variations in density, such as those caused by temperature and pressure gradients, can affect the residence time and are superimposed on effects due to velocity variations and micromixing. In practice, it is difficult to assess each of these factors, and so a mean residence time can be approximated by:

$$\theta = \frac{V}{Q}$$

where V is approximately the volume of the combustion chamber and Q is the actual volumetric flow rate of combustion product gas leaving the chamber. Since Q is also a function of temperature, residence time is inversely proportional to temperature, i.e., as combustion temperature increases, residence time decreases, other factors being equal. Strictly speaking, V is the volume through which combustion gases flow after they have been heated to reaction temperature. However, if mixing is adequate, the total combustion chamber volume is a good approximation for V.

2.1.1.5 Mixing--

Residence time, temperature, and combustion air requirements all depend to some extent on the degree of mixing achieved in the combustion chamber. The degree of mixing is a function of the specific burner design, the flow pattern in the combustion chamber, and the turbulence achieved. The Reynolds number is a dimensionless quantity used to quantify turbulence, and is defined as:

$$Re = \frac{Dv\rho}{\mu}$$

where: D = combustion chamber inside diameter, ft
v = gas velocity, ft/s
ρ = gas density, lb/ft^3
μ = absolute gas viscosity, lb/ft.s

At $Re > 2300$, flow is considered turbulent. Below this number, laminar or transitional flow prevails, and mixing is essentially by diffusion only.

2.1.2 Combustion of Solids

2.1.2.1 Physical/Chemical Properties--

Just as liquid droplet size affects the combustion rate of liquid fuels, particle size has an influence on the rate of combustion of solids. Combustion of solids involves a series of repeated steps. First, volatile material near the surface is burned, followed by burnout of the residual solid structure. Fresh unreacted solid is then exposed as the initial ash layer drops off, and the process is repeated. Thus, the larger the solid particle, the greater the number of times this sequence must be repeated, and the longer the residence time required for complete combustion. Due to this mechanistic difference between solid and liquid combustion, design residence times for solids are generally longer than for liquids. In fact, solids are often incinerated in a system which volatilizes the solid (or nonpumpable liquid) in one chamber and incinerates the resulting gases in an afterburner.

The elemental composition, moisture, and heating value of solids are as important in assessing combustion characteristics as they are for liquids (see Section 2.1.1.1). However, inhomogeneity of the fuel is a greater concern for solids. Therefore, steps should be taken to provide as uniform a feed as possible when incinerating solids.

2.1.2.2 Combustion Air--

Computation of the theoretical air requirement for solids is essentially the same as the procedure for liquids. However, since solid particles are generally larger than droplets of atomized liquids and air/fuel mixing is less efficient, more excess air is generally required for combustion of solids.

2.1.2.3 Temperature--

When incinerating solids, temperatures must be high enough to volatilize, partially oxidize, or otherwise convert the organic components of the waste to gases and also high enough to degrade thermally these volatilized organics. Furthermore, such reactions must occur within the residence time of the equipment. As with liquids, equipment design will determine a maximum allowable combustion temperature. Characteristics of the solid will determine a minimum combustion temperature.

2.1.2.4 Residence Time--

The residence times for solids in incineration equipment must be longer than residence times for liquids in order to achieve comparable destruction efficiencies. Often separate chambers in the equipment are used: first to volatilize the organic components of the solid, then to complete the combustion process in another chamber or afterburner. In such cases the residence time in each chamber should be known (or estimated). Solids residence time in the first section must be at least long enough to fully volatilize the PCBs in the charge. Gas residence time in the afterburner should then be assessed to ensure the desired thermal destruction efficiency.

2.1.2.5 Mixing--

The degree of both air/solid contact and gas mixing must be assessed in determining whether adequate mixing is achieved when incinerating solids. The mechanical means of air/solid contact vary with equipment type, and are discussed for several equipment designs in Section 2.2. Gas mixing is discussed in Sections 2.1.1.5 and 4.1.1.3.

2.2 THERMAL DESTRUCTION SYSTEMS

Thermal destruction processes described in this section are grouped into the following general categories:

- Incineration systems

- High efficiency boilers

Some of these thermal destruction processes have been tested for PCB disposal, while others have been tested for disposal of other hazardous wastes. Not all the systems described are suitable for thermal destruction of PCBs.

The following incineration systems have received the most attention in the literature and are technologically well developed for waste destruction:

- Liquid injection
- Rotary kiln
- Multiple hearth
- Fluidized bed
- Multiple chamber
- Catalytic combustion
- Pyrolysis

Several other thermal destruction processes which are not as technologically well developed for waste disposal are:

- Starved air combustion
- Molten salt
- High efficiency boilers

2.2.1 Incineration Systems

2.2.1.1 Rotary Kiln--

2.2.1.1.1 Description--The rotary kiln incinerator is a cylindrical refractory-lined shell that is mounted horizontally at a slight incline. Wastes are fed into the uphill end. Rotation of the shell causes mixing of the waste with combustion air in order to provide sufficient turbulence and agitation for adequate destruction of the waste. It is sometimes necessary to install a secondary high temperature combustion chamber to complete the destruction of vapor phase and particulate materials. For incinerating chlorinated wastes, a scrubber is necessary for control of HCl emissions. Figure 2 is a schematic of a rotary kiln typical of those used by contract waste disposal facility operators (11).

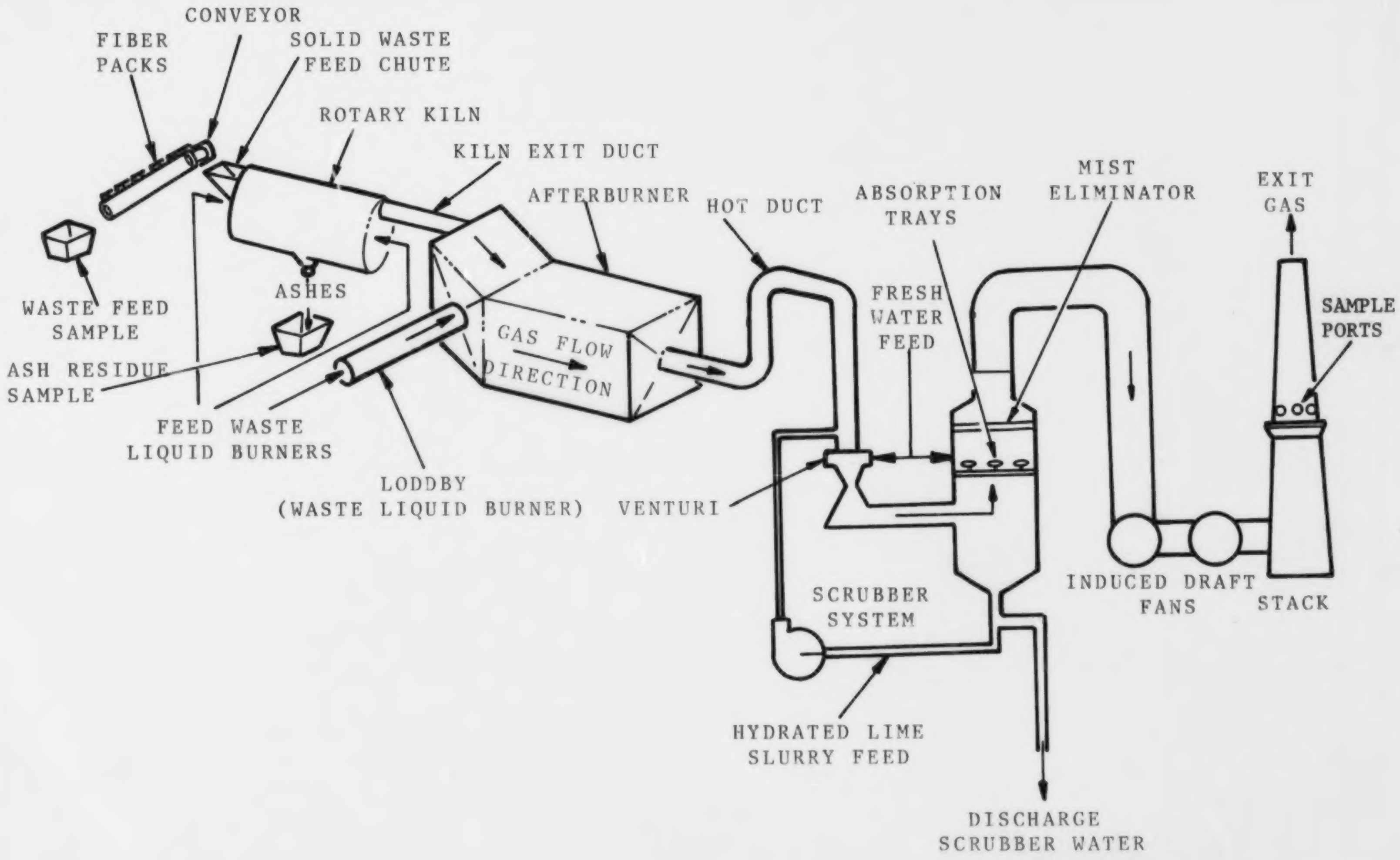

CONVEYOR
FIBER PACKS
SOLID WASTE FEED CHUTE
ROTARY KILN
KILN EXIT DUCT
AFTERBURNER
HOT DUCT
ABSORPTION TRAYS
MIST ELIMINATOR
EXIT GAS
SAMPLE PORTS
WASTE FEED SAMPLE
ASHES
FRESH WATER FEED
GAS FLOW DIRECTION
ASH RESIDUE SAMPLE
FEED WASTE LIQUID BURNERS
LODDBY (WASTE LIQUID BURNER)
VENTURI
INDUCED DRAFT FANS
STACK
SCRUBBER SYSTEM
HYDRATED LIME SLURRY FEED
DISCHARGE SCRUBBER WATER

Figure 2. Schematic of Rollins Environmental Services rotary kiln incinerator (11).

Combustion temperatures in a rotary kiln incinerator typically range from 800°C to 1300°C. Since rotary kiln incinerators are normally completely refractory-lined, they are more resistant to damage by high temperatures than other types. Residence times vary from seconds for liquids to hours for solids.

Some rotary kilns are designed for batch feeding. Others are equipped with liquid injection chambers after the rotary kiln. Both of these systems provide great flexibility in terms of wastes that can be destroyed. Rotary kilns are particularly effective when the size or nature of the waste precludes the use of other types of incineration systems.

2.2.1.1.2 Advantages

- Ability to handle both liquids and solids, either alone or in combination
- Ability to operate at very high temperatures
- Feed system design flexibility and ability to feed large containers
- Good mixing of air and solids
- Continuous ash removal
- No moving parts inside the kiln hot zone
- Solids residence time easily adjusted by varying rotational speed of kiln
- Not necessary to pretreat waste prior to incineration
- Cement kilns represent a possible PCB disposal system with resource recovery potential

2.2.1.1.3 Disadvantages--

- Seals on kiln ends and feed chute may leak
- Careful attention to temperature in the kiln is necessary to prevent refractory damage
- Emission of particulates, especially unburned particulates, can be a problem. Particulate emission control is necessary
- Relatively low thermal efficiency
- High capital cost

2.2.1.1.4 Facilities and Test Data--A typical rotary kiln installation is the facility at Rollins Environmental Services, Inc. (RES) in Deer Park, Texas. The basic components of this rotary kiln system are:

- Rotary kiln incinerator
- Liquid injection burner
- Afterburner
- Venturi scrubber with mist eliminator
- Waste and auxiliary fuel feed controls
- Instrumentation
- Ash and scrubber effluent handling

The rotary kiln is 4.9 meters long and 3.2 meters in diameter. Flame temperature in the kiln is nominally 1300°C. Maximum total heat release is 28 million kcal/hr. The liquid injection burner is 4.9 meters long and 1.6 meters in diameter and produces a flame temperature of approximately 1500°C. As can be seen in Figure 2, the rotary kiln and liquid injection burner both feed the afterburner which is 10.6 meters long, 4 meters high, and 4.3 meters wide. Because the afterburner section is downstream of the liquid injection burner, typical afterburner gas temperatures are about 1300°C. The gas residence time of this system is of the order of 2-3 seconds. Both the kiln and the liquid injection burner are equipped with natural gas ignitors and gas burners for initial heating of the refractory lining, flame stability during incineration, and supplemental heat if necessary. Number 2 fuel oil is used as auxiliary fuel if wastes have insufficient heat content.

Solid wastes are usually packed in fiber drums and are fed into the kiln by conveyor. Metal cans as large as 55-gallon drums can also be fed to the kiln. Liquids and sludges can be pumped into the kiln. Liquids can also be fed into the liquid injection burner.

Atmospheric emissions from incineration of liquid and solid wastes are controlled by a venturi scrubber. After being scrubbed, the combustion gases pass through absorption trays and a mist eliminator before entering a 30 meter high stack. Spent scrubber water is neutralized with lime and sent to settling ponds where it is analyzed and given additional treatment, if necessary, before discharge.

PCB destruction tests at RES were conducted in December 1976 and reported by Ackerman, et al. (11,12). These tests involved incineration of: 1) whole PCB-containing capacitors and 2) PCB-containing capacitors hammermilled into "fluff". The PCB mixture was determined to be Aroclor 1242, and its heat content was such that it would not ignite in a bomb calorimeter (i.e., less than 3000 kcal/kg or 5,000 Btu/lb). The capacitors contained 29% PCBs. Whole capacitors were fed to the rotary kiln at about 360 kg/hr; the fluff, packed into 135 liter (35 gallon) fiber drums, was fed at a rate of about 210 kg/hr. The following tests were conducted: 1) background while burning No. 2 fuel oil; 2) hammermilled capacitors followed by a purge with No. 2 fuel oil; and 3) whole capacitor. No. 2 fuel oil and natural gas were used to supply additional heat during the tests. Hot zone (between the afterburner and the scrubber), stack, ash, and scrubber water samples were taken. On-line combustion gas monitoring was performed in the hot zone for O_2, CO_2, CO, NO_x, SO_2, HCl, and hydrocarbons. Nitrogen was obtained by difference.

Process data acquired were natural gas and fuel oil feed rates to the kiln and liquid burner; temperatures in the kiln, liquid burner, afterburner, and hot zone; combustion air; fresh scrubber water feed; and lime slurry feed. Table 1 presents a summary of operational data.

PCBs were not detected in any combustion gas (detection limit of 5 $\mu g/m^3$) or scrubber water sample (detection limit of 7 µg/l). PCBs were detected in the solid residues from the whole capacitor test at a level of 470 mg/kg but were not detected in the ash from the hammermilled capacitor test (detection limit of 0.1 mg/kg). Calculated PCB destruction efficiencies were (air, water, solid):

- Whole capacitors: 99.5%
- Hammermilled capacitors: >99.999%

HCl scrubbing efficiency was 99.8%.

In November 1979, a PCB Trial Burn was conducted at RES (13,14). The facility was essentially the same as that described above except that monitoring instrumentation and process controls had been upgraded in compliance with the PCB Regulations (40 CFR 761.40(d)(1)). A background test (high heating value organochlorine waste) and three short duration PCB incineration tests were conducted using the liquid injection burner.

This PCB Trial Burn involved burning liquid PCBs with the liquid injection burner of the rotary kiln system. Projected feed rates were: 1) PCBs, 2270 ± 450 kg/hr, and 2) auxiliary fuel, 1140 ± 360 kg/hr. Stack gases were monitored for O_2, CO, CO_2, NO_x, and SO_2. Samples of stack gas were taken for analysis of PCBs, organochlorine compounds, polychlorinated dibenzofurans, HCl, and total particulate matter. Other process influent and effluent streams were taken for analysis of PCBs, PCDFs, and PCDDs.

TABLE 1. OPERATIONAL DATA FROM PCB TESTS AT ROLLINS ENVIRONMENTAL SERVICES (12)

	Test		
	1, Fuel Oil	2, Fluff	3, Whole Capacitors
O_2, %	10.1	9.8	10.1
CO_2, %	9.1	8.8	5.0
CO, ppm			
Fuel Oil Feed, l/hr	2088	2411	2300
PCB Waste Feed, kg/hr*	--	61	104
Kiln Flame, °C	1306	1252	1338
Liquid Burner Flame, °C	1485	1499	1509
Afterburner, °C	1308	1331	1332
Hot Zone, °C	1091	1089	1096
Residence Time, sec.	--	3.2	3.0
Scrubber Water, l/min	3200	3200	3200
Lime Slurry Feed, l/min†	6.4	6.4	8.4

* Fluff was 29% PCBs, fluff feed rate was 210 kg/hr, fluff plus fiber drum feed rate was 330 kg/hr. Whole capacitor feed rate was 360 kg/hr.

† Approximately 30% by weight of lime.

Process parameters monitored were: feed and PCB feed rate; temperatures in the liquid burner, afterburner, hot zone, combustion air; fresh scrubber water and lime slurry feed; stack gas composition; and combustion efficiency.

Upgrading of the process instrumentation to be in accordance with the PCB Regulations included stack gas monitoring instrumentation and interlocks which shut off PCB feed unless each of the following conditions were met:

- CO, <80 ppm
- O_2, >3%
- Afterburner exit, 1142°C (2088°F)

This interlock system did function. During switchover from background fuel to PCB waste, the target PCB feed rate was momentarily exceeded, and the control operator increased air feed rate to maintain the required excess air until the outside operator could reduce the PCB feed rate. When the PCB rate was reduced to the target level, the afterburner exit temperature dropped to the shutdown temperature of 1116°C (2040°F) before the air feed rate could be reduced. The PCB feed was thus shut down. Temperatures were then brought to requirements with background fuel, switchover to PCBs was made again, and the test proceeded without other incidents (14).

Combustion efficiencies during the two PCB tests averaged 99.993%. Stack gas samples showed no detectable quantities of PCBs (detection limit of 1 ppb), no PCDFs, and no organochlorine. Scrubber effluent samples showed 1 ppb PCBs at the outlet and undetectable levels at the discharge from the scrubber effluent treatment system. The average PCB destruction efficiency was 99.99997%. All technical requirements for Annex I Incinerators were met (14).

In October 1979, a PCB Trial Burn was conducted at a rotary kiln incinerator operated by Energy Systems Company (ENSCO), El Dorado, Arkansas (15,16). The ENSCO facility is somewhat different in configuration from that of RES, see Figure 2. There is a totally enclosed shredder for shredding solids. A conveyor moves solids from the bottom of the shredder to the rotary kiln (10.4 m long, 2.1 m diameter). Sludge, semi-solids, and slurries are fed into the bottom of the enclosure. A fan pulls air from the enclosure and forces it into the rotary kiln. The outlet gases from the kiln pass into a cyclone for ash removal. Flue gases then pass sequentially through a 85 m^3 (3000 ft^3) combustion chamber and through a second 85 m^3 secondary combustion chamber. Liquid wastes and additional combustion air can be fed into the primary combustion chamber. From the secondary combustion chamber, flue gases pass into a venturi scrubber, then into a cyclone demister, and finally to a stack. HCl is neutralized in the scrubber by lime and caustic, and spent scrubber water is sent to a sludge lagoon.

Tests were conducted on shredded electric utility and small electronic capacitors and liquid PCBs. The liquid PCBs were mixed with the shredded capacitors, so that there was only one feed stream. Target feed rates were 909 kg/hr (2000 lb/hr) of shredded capacitors (∿ 25% PCBs) and 450 kg/hr (1000 lb/hr) of PCB oil (∿ 81% PCBs). The PCB mixture was Aroclor 1016. Auxiliary fuel was an organochlorine waste of approximately 40% chlorine content. The following samples were taken: stack gas, ambient air and surrounding soil, shredded capacitors, fuel, kiln ash and slag, well water, recycled and spent scrubber solution, caustic feed, and lime slurry.

Process parameters monitored were: rate and quality of small and large capacitors and liquid PCBs fed; fuel feed rate; process temperatures; caustic solution, lime slurry, recycled scrubber solution, and scrubber effluent; well water feed to the primary combustion chamber; kiln ash and its PCB content; ambient wind speed and direction; combustion gas composition; and combustion efficiency.

Process instrumentation installed to comply with the PCB regulations had the following interlocks to shut down the PCB feed rate if:

- Kiln temperature, <650°C (1200°F)
- Kiln draft, <0.05 in. water
- Afterburner termperature, <1120°C (2050°F)
- Afterburner draft, >atmospheric pressure
- CO, >48-50 ppm
- O_2, <4.5%

The interlock system did function on a few occasions when CO concentrations momentarily exceeded 48-50 ppm.

Table 2 presents a summary of operational parameters. Combustion efficiency, based on CO and CO_2 measurements, was above 99.9%. PCBs were not detected in the stack gas (detection limit was 100 pg/train) or the scrubber effluent (detection limit for decachlorobiphenyl was 4 ppb). Traces of PCBs were detected in the kiln ash but at levels well below 50 ppm. This Trial Burn met all requirements of the PCB Regulations (16). There was a problem with false positives in the analysis of the samples (see Section 2.3.2.2.2).

As part of a program to develop methods for determining PCB emissions from incinerators and capacitor and transformer filling plants, Haile and Baladi (17) reported on field tests conducted while PCBs were being incinerated at Rollins Environmental Services, Deer Park, Texas.

At the RES tests, shredded capacitors containing approximately 17% PCBs were burned on one day, and whole capacitors were burned on the second. No operational data, PCB input rates, or destruction efficiencies were given. Average stack emissions from the test at RES was 0.74 ng/m^3 as decachlorobiphenyl.

No other references to thermal destruction of PCBs in rotary kiln incinerators have been found. 3M Company's Chemolite rotary kiln incinerator was tested (11,18) while incinerating a waste stream resulting from manufacture of polyvinyl chloride. The design of this system is similar to that of RES and ENSCO, except that there is a water quench chamber between the secondary combustion chamber and the venturi scrubber. During these tests the kiln was operated at 870°C, the secondary combustion chamber was operated between 980 and 1090°C, and the gas residence time was 3 seconds. Oxygen in the stack ranged from 11 to 11.4%, CO_2 ranged from 6.1 to 6.3%, and CO ranged from 14 to 20 ppm. Waste destruction efficiencies ranged from 99.8 to 99.88%

There are other rotary kiln incinerators in operation. Dow, U.S.A., operates a large rotary kiln unit (70 million Btu/hr) in Midland, Michigan (10,19). Chemical Agent munitions (9) operates a rotary kiln unit. Test data as detailed as those presented above were not available.

MacDonald, et al. (20) reported on PCB destruction tests at a cement kiln at the St. Lawrence Cement Co. in January 1976. Ackerman, et al. (11,21) reported results of analyses on samples taken during the tests. While the rotary kiln tested was not designed and used as an incinerator, temperatures reached in the kiln were of the order of those reached in an

TABLE 2. OPERATIONAL DATA FROM PCB INCINERATION TESTS AT ENSCO (16)

	Background	Test 1	Test 2	Test 3	Average, PCB Tests
O_2, %	14.2	13.2	13.8	13.1	13.4
CO_2, %	4.5	5.8	4.9	5.6	5.4
CO, ppm	10	6	4	4	5
Fuel Feed, kg/hr	2,584	2,909	3,032	2,766	2,963
Natural Gas Feed, m^3/hr	312	88	37	67	64
Liquid PCB Feed, kg/hr*	--	164	176	196	179
PCB in Capacitors†	--	119	98	114	110
Temperature, Outlet of First Comb. Chamber, °C	1,270	1,250	1,240	1,254	1,250
Temperature, Outlet of Second Comb. Chamber, °C	1,050	1,040	1,043	1,050	1,040
Caustic, gal/hr‡	634	734	849	592	725
Lime Slurry, lb/hr**	--	6,687	7,198	4,370	6,085

* Liquid PCB feed was 80.9% PCBs. Average PCB oil feed was 221 kg/hr (179 $kg \cdot hr^{-1}$/0.809).

† Capacitors averaged 24.8% PCBs. Average capacitor feed rate was 444 kg/hr (110 $kg \cdot hr^{-1}$/0.248).

‡ 50% NaOH by weight, 12.7 lb/gal.

** 38% wt. % solids; solids are 85% $Ca(OH)_2$, 10.54 lb/gal. Average heat input was 56 x 10^6 Btu/hr.

incinerator. It was judged that burning organochlorine wastes would have two benefits: 1) reduction in petroleum fuel fed to the cement kiln and 2) reduction in the amount of extra chloride necessary to reduce the alkali content in the product cement.

Tests were conducted on two different unit processes (20). The first was the wet process and consisted of a 123 m long by 3.5 m diameter kiln maintained at 1450°C by firing No. 6 fuel oil. The second unit process was a suspension preheater kiln. This kiln was 84 m long, 5.2 m in diameter, and maintained at 1450°C by firing No. 6 fuel oil. Process raw materials are fed into the flame end of the kilns, which slope gradually downward. The downstream ends of both kilns fed into finished product and clinker collection devices and emission control devices.

PCB destruction tests were conducted on a complex organochlorine waste containing approximately 45% PCBs. Normal cement kiln operation process data were taken. Also, the PCB mixture input rate and gas flow rates in the stack were monitored. PCBs were not detected in the stack gas, particulate, or clinker samples. The destruction efficiency of PCBs was calculated to be 99.986%, and it was probably greater because of high background levels in the samples and small sample sizes. Residence time was estimated to be of the order of 30 seconds (20).

Continental Can Company operates a pulp and paper mill at Hopewell, Virginia. In 1976, EPA Region III received information that waste oil supplied to Continental for operating its rotary lime kiln and power/steam boilers was contaminated with PCBs (22). Upon confirming that the oil was contaminated, EPA conducted emissions testing on kiln No. 3. This unit is 79.8 m long and 3.4 m in diameter. The kiln normally operates 24 hr/day and 7 days/week. Its design production rate is 226 metric tons per day. During testing it operated at 182 metric tons per day.

The kiln is equipped with instrumentation to indicate hot and cold end kiln temperatures, fuel oil feed rate, lime and mud flow rate, and percent solids in the lime slurry. The waste oil fired during testing averaged 2.4 ppm PCBs. The kiln operated at 1260°C during the tests. No oxygen data were taken. There were several problems during the single test on lime kiln No. 3: 1) the test could not be conducted within 10% of isokinetic, 2) an acceptable leak rate could not be achieved, and 3) several sampling parts were inaccessible. The test was considered invalid although a destruction efficiency of 95.4% was reported (22).

A PCB destruction test was performed in December 1976 in a cement kiln at Peerless Cement Co. in Detroit, Michigan. Two background and three PCB destruction tests were performed. Kiln temperatures ranged from 1273°C to 1389°C. Calculated residence time was 10 sec. Destruction efficiencies derived from the summary reqport (23) averaged 99.9983%.

Several waste destruction tests were performed in a rotary cement kiln in Sweden by the Swedish Water and Air Pollution Research Institute (24). One of the wastes was 375 g/l of Aroclor 1242 in oil. Destruction efficiency for the PCB test was 99.99998%.

2.2.1.2 Liquid Injection--

2.2.1.2.1 Description--Liquid injection incinerators can be used to dispose of virtually any combustible liquid with a viscosity low enough to be pumped (< 10,000 SSU). This type of incinerator is made in numerous configurations, but they are generally classified as vertical or horizontal units. The vertical incinerator type, Figure 3, has the advantage that the incinerator acts as its own stack. The stack, or a portion of it, may serve as a secondary combustion chamber. Horizontal incinerators, Figure 4, are connected to a stack. The vertical type is not as well suited to tall stacks as the horizontal type.

Liquid injection incinerators have the following general components: burner, primary combustion chamber, secondary combustion chamber (or stack), quench chamber, scrubber, and stack. The heart of any liquid injection incinerator is the burner. Efficient and complete combustion is achieved only if the fuel droplet size is sufficiently small and adequately mixed with the combustion air (see Section 2.5.2 for a discussion of fundamental combustion process parameters). Atomization of the fuel is typically achieved by: 1) rotary cup, 2) pressure atomization, or 3) gas/fluid nozzles using high pressure air or steam.

2.2.1.2.2 Advantages--

- Ability to handle a variety of liquid wastes, the range of which is determined by burner type

- Fast response of temperature to changes in fuel/waste feed
- No moving parts in the combustion chamber
- Capability of operating over wide range of feed rates (high turndown ratio)
- Low maintenance cost

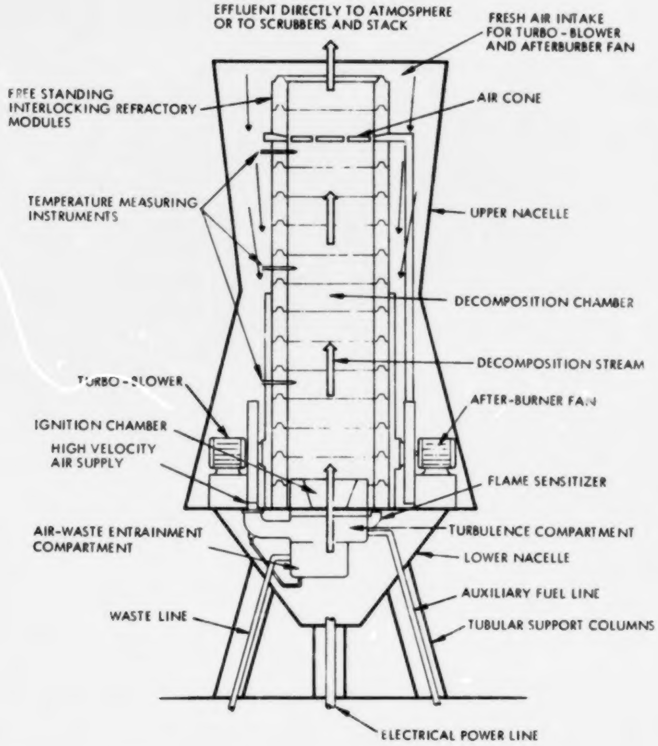

EFFLUENT DIRECTLY TO ATMOSPHERE OR TO SCRUBBERS AND STACK
FRESH AIR INTAKE FOR TURBO - BLOWER AND AFTERBURBER FAN
FREE STANDING INTERLOCKING REFRACTORY MODULES
AIR CONE
TEMPERATURE MEASURING INSTRUMENTS
UPPER NACELLE
DECOMPOSITION CHAMBER
DECOMPOSITION STREAM
TURBO - BLOWER
AFTER-BURNER FAN
IGNITION CHAMBER
HIGH VELOCITY AIR SUPPLY
FLAME SENSITIZER
AIR-WASTE ENTRAINMENT COMPARTMENT
TURBULENCE COMPARTMENT
LOWER NACELLE
AUXILIARY FUEL LINE
WASTE LINE
TUBULAR SUPPORT COLUMNS
ELECTRICAL POWER LINE

Figure 3. Typical vertically fired liquid waste incinerator (25).

2.2.1.2.3 Disadvantages--

- Liquids incinerated must have viscosities low enough not only to be pumped, but to be atomized in the burner.
- Burners are subject to plugging, erosion, and corrosion from incompatible fluids.
- Sophisticated instrumentation is required to maintain combustion efficiency.

2.2.1.2.4 Facilities and Test Data--In September, 1974 EPA's Region I arranged to test the incineration of 1540 gallons of a 20% DDT formulation in General Electric Company's horizontal liquid injection incinerator in Pittsfield, Massachusetts (27). The tests were a joint effort of EPA Region I, General Electric, and the Massachusetts Department of Public Health. The primary use of the incinerator is to destroy site-generated waste oils, frequently contaminated with PCBs. During the tests, waste oil contaminated with about 1.7% PCBs was used as auxiliary fuel.

GE's incinerator system consists of two steam atomization burners, a long cylindrical chamber to provide sufficient residence time, a water spray quench pot, a counter current packed scrubber column located at the base of the stack, and appropriate control systems. The nozzles inject the waste along with combustion air and produce vortex-type turbulence. The oxidation chamber is 8.2 m (27 ft) long by 2.1 m (7 feet) in diameter, is operated typically at 871 to 982°C (1600 to 1800°F), and provides about 3 seconds residence time.

The testing consisted of: 1) background with firing of waste oil only (ca 1.7% PCBs), 2) two tests at 871°C firing waste oil (0.75 and 0.8 gpm) and the DDT formulation at 0.5 and 0.8 gpm, and 3) two tests at 982°C firing waste oil and the DDT formulation at 0.5 and 0.8 gpm.

There were five tests, a background with firing only waste oil and four tests at two temperature conditions (871 and 982°C) at two DDT formulation feed rates. Waste oil was fed during the four DDT tests at a rate about half that of the background test. PCB destruction efficiencies were: 1) 99.997% during the background, 2) 99.9995% and 99.9921% at 871°C, and 3) 99.9941% and 99.9951% at 982°C (27).

As part of a program to develop methods for determining PCB emissions from incinerators and capacitor and transformer filling plants, Haile and Baladi (17) reported on a field test while PCBs were being incinerated at an industrial facility identified as Plant B. Plant B incinerates liquid waste only, and a waste containing approximately 10% PCBs was incinerated during the test reported by Haile and Baladi. No operational data, PCB feed rates, or destruction efficiencies were given. PCB emissions averaged 177 ng/m^3 as decachlorobiphenyl.

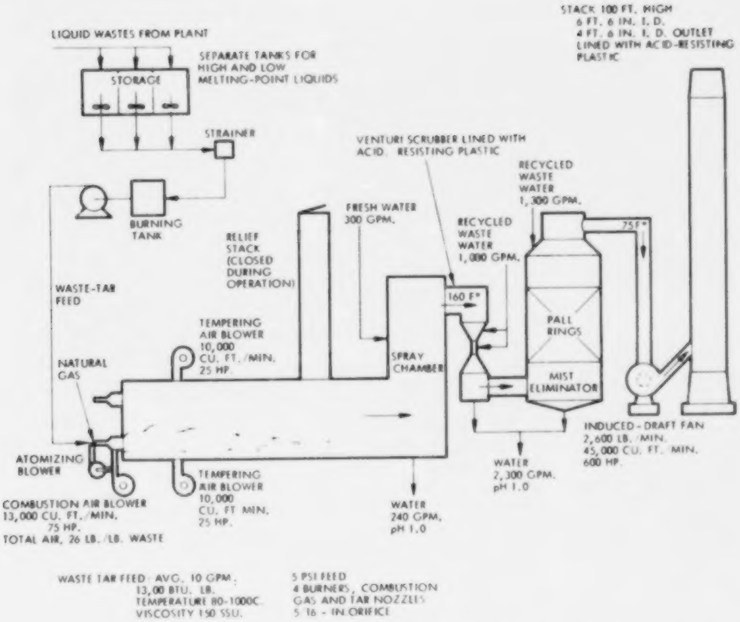

LIQUID WASTES FROM PLANT
SEPARATE TANKS FOR HIGH AND LOW MELTING-POINT LIQUIDS
STORAGE
STRAINER
BURNING TANK
WASTE-TAR FEED
RELIEF STACK (CLOSED DURING OPERATION)
TEMPERING AIR BLOWER 10,000 CU. FT./MIN. 25 HP.
NATURAL GAS
ATOMIZING BLOWER
COMBUSTION AIR BLOWER 13,000 CU. FT./MIN. 75 HP.
TOTAL AIR, 26 LB./LB. WASTE
TEMPERING AIR BLOWER 10,000 CU. FT. MIN. 25 HP.
WATER 240 GPM. pH 1.0
FRESH WATER 300 GPM.
SPRAY CHAMBER
VENTURI SCRUBBER LINED WITH ACID. RESISTING PLASTIC
160 F°
RECYCLED WASTE WATER 1,000 GPM.
RECYCLED WASTE WATER 1,300 GPM.
PALL RINGS
MIST ELIMINATOR
75 F°
WATER 2,300 GPM. pH 1.0
STACK 100 FT. HIGH
6 FT. 6 IN. I. D.
4 FT. 6 IN. I. D. OUTLET
LINED WITH ACID-RESISTING PLASTIC
INDUCED-DRAFT FAN 2,600 LB./MIN. 45,000 CU. FT./MIN. 600 HP.
WASTE TAR FEED: AVG. 10 GPM.; 13,00 BTU. LB. TEMPERATURE 80-1000C. VISCOSITY 150 SSU.
5 PSI FEED
4 BURNERS, COMBUSTION GAS AND TAR NOZZLES
5/16 - IN ORIFICE

Figure 4. Horizontally fired liquid waste incineration system (26).

It should be noted that several rotary kiln incinerators described in Section 2.2.1.1 were equipped with liquid injection burners for incinerating liquid wastes. RES, Figure 1, has a liquid burner in the secondary combustion chamber. ENSCO's unit has liquid injection burners in the rotary kiln section and the primary combustion chamber (15). The liquid injection systems of these two incinerators can be viewed as horizontal incinerators.

Several detailed reports on testing of commercial scale liquid injection burner incinerators with hazardous wastes were found. They are briefly described below.

The Marquardt Company operated a typical liquid injection incinerator. The system consisted of a specially developed burner, Marquardt Sudden Expansion (SUE ^{R}) burner; air, waste, and auxiliary fuel systems; a mixing/afterburner; and a venturi/caustic scrubber. This is a horizontal incinerator. The combustion section of the incinerator is designed for feed rates of 190-230 liters per hour, a maximum wall temperature of

1650°C, and residence times of 0.1 to 0.2 seconds (11,28). Tests were conducted on ethylene and hexachlorocyclopentadiene wastes. Samples of process effluents were taken: stack gas, solid residues, scrubber water. Process parameters are presented in Table 3.

The United States Air Force conducted tests (29,30) at Marquardt on thermal destruction of its stocks of Herbicide Orange, which were contaminated with approximately 1.5 ppm of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). Combustion gas monitoring was performed, and samples of stack gas, scrubber water, and burner head residue were taken and analyzed. Neither Herbicide Orange esters nor TCDD was found in combustion zone and stack gas and scrubber water samples. One injector nozzle was less efficient and promoted coke formation, a trace of unburned esters was found in the coke deposits around the nozzle. A second type of nozzle, a slot type, promoted much less coke formation. Combustion zone temperatures ranged from 1245 to 1522°C. Destruction efficiencies were not given explicitly but were in excess of 99.9%.

An extensively tested liquid injection incineration system is the one onboard the M/T Vulcanus, a chemical waste incinerator ship. This vessel, originally a freighter, was converted into a tanker and then into an incinerator ship which meets all international requirements for carriage of hazardous cargoes. She has a cargo capacity of 3,503 m^3. There are two vertical incinerators at the stern. The combustion chambers are 3.4 m ID and 4.3 m high. Above the combustion chamber, there is a 1.6 m section tapering to a straight stack, 4.6 m high and 3.4 m ID. Three rotating cup vortex burners are located approximately equidistantly on the periphery and near the base of each incinerator. The Vulcanus burns only liquids. The incinerators are heavily instrumented and have several failsafe waste feed shutoff systems. The M/T Vulcanus has been extensively tested while burning organochlorine wastes. Table 4 presents a summary of results of testing. The Vulcanus has been tested four times under EPA cognizance. Wastler, et al. (31) and Clausen, et al. (32) reported on the incineration of industrial organochlorine wastes in the Gulf of Mexico.

TABLE 3. RESULTS OF INCINERATION TESTS OF ETHYLENE AND HEXACHLOROCYCLOPENTADIENE WASTES AT THE MARQUARDT COMPANY (11,28)

	Ethylene Waste	Hexachlorocyclopentadiene Waste
O_2, %	4.9 - 9.4	5.5 - 8.6
CO_2, %	9.3 - 11.5	8.4 - 9.7
CO, ppm	17 - 22	17 - 20
Waste Feed Rate, kg/hr	84 - 120	40 - 90*
Combustion Temperature, °C	1349 - 1752	1348 - 1378
Residence Time, sec.	0.14 - 0.19	0.17 - 0.18
Destruction Efficiency, %	>99.999	>99.999

*Hexachlorocyclopentadiene feed rate only. Waste feed was a mixture of No. 2 fuel oil plus hexachlorocyclopentadiene at a rate of 120-174 kg/hr.

TABLE 4. RESULTS OF SEVERAL INCINERATION TESTS OF ORGANOCHLORINE WASTES ONBOARD THE M/T VULCANUS

	Organochlorine Waste (31)	Organochlorine Waste (32)	Herbicide Orange (33)
O_2, %	9-12.5	10.07	8.9
CO_2,%	--	9.22	10.3
CO, ppm	25-75	25.5	10
Waste Feed, mt/hr	24.5	22	14.6
Flame Temperature, °C	1550	1535	1500
Wall Temperature, °C*	1210	1238	1273
Wall Temperature, °C†	1138	1186	1167
Residence Time, sec.	∿1	0.9	1.01
Heat Input, 10^7 Kcal/hr	8.1	8.5	8.1
Waste Destruction Efficiency, %	>99.9	>99.98	>99.999‡

*Thermocouple located about 1.3 cm from inside wall.

†Thermocouple located about 4 cm from inside wall.

‡Average TCDD destruction efficiency was >99.93% (34).

Ackerman, et al. (33) and Ackerman (34) reported on the at-sea incineration of TCDD-contaminated Herbicide Orange in an incineration site in the Pacific Ocean. Ackerman, et al. (35) reported on combustion gas monitoring during incineration of European organochlorine industrial wastes in the North Sea.

Process instrumentation is minimal but adequate, for this is a well designed system. Each incinerator has three thermocouples. One is located about 1.3 cm from the inside wall on the same level as the burners. These are the "indicator" thermocouples, and they have readouts on the bridge and the incinerator control panel. The second is located about 4 cm from the inside wall on the same level as the burners. These are the "controller" thermocouples, and they serve the automatic waste feed shutoff system. The third is located in the straight portion of the stack, and they have readouts on the bridge and in the incinerator control panel. There are differential manometers on the waste feed lines which give indications of flow restrictions. Waste feed rates are measured by gauging the tanks. There are automatic sensors which shut off the waste feed pumps if: 1) a burner is extinguished, 2) waste feed is terminated from plugging of the lines, and 3) air feed is reduced below a certain point. According to current international regulations, the Vulcanus and any other incineration vessel will have to install additional instrumentation for CO, CO_2, O_2, and waste feed rate measurements. Heretofore, however, the Vulcanus has operated very efficiently by feeding waste at a rate sufficient to produce incinerator temperatures above 1200°C and below 1500°C.

2.2.1.3 Multiple Hearth--

2.2.1.3.1 Description--The multiple hearth incinerator (Herreshoff furnace) was first developed to incinerate sewage sludges. Since then, it has found application in disposal of other wastes, including tars, solids, liquids, and gases. The multiple hearth furnace, Figure 5, consists of a refractory-lined cylindrical steel shell with refractory hearths mounted one above the other in the interior of the shell. A rotating air-cooled central shaft turns air-cooled rabble arms equipped with teeth across the hearths. The rabble arms plow burning solids to move across the hearths and to fall through drop holes from the upper hearth to succeeding lower hearths and

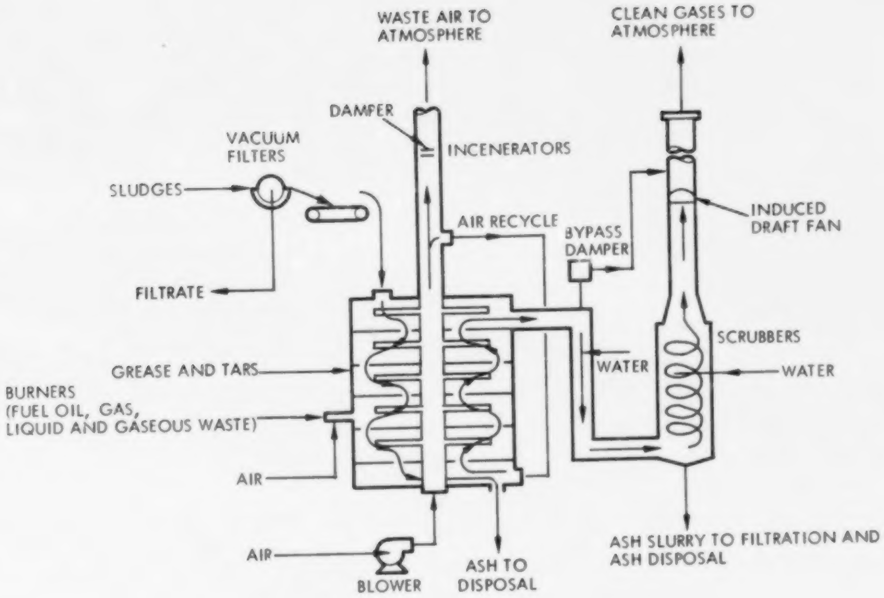

WASTE AIR TO ATMOSPHERE
CLEAN GASES TO ATMOSPHERE
DAMPER
VACUUM FILTERS
INCENERATORS
SLUDGES
AIR RECYCLE
BYPASS DAMPER
INDUCED DRAFT FAN
FILTRATE
SCRUBBERS
GREASE AND TARS
WATER
WATER
BURNERS (FUEL OIL, GAS, LIQUID AND GASEOUS WASTE)
AIR
AIR
BLOWER
ASH TO DISPOSAL
ASH SLURRY TO FILTRATION AND ASH DISPOSAL

Figure 5. Multiple hearth incineration system (36).

eventually to an ash recovery hopper. Solids are fed into the top, viscous liquids are fed in through side ports, and light liquids and gases are fed in through auxiliary burner nozzles. Using combustible liquid and gaseous wastes reduces the amount of hydrocarbon fuels required.

Furnaces range in size from 1.8 m to 7.6 m in diameter and 3.6 m to 23 m high. Six hearths are normally the minimum number used, but the actual number needed depends on the waste fed, desired solids residence time, and whether the process will be operated as an incinerator or a pyrolysis unit (37).

2.2.1.3.2 Advantages--

- Solids residence times achieved are long enough to volatilize PCBs from shredded capacitors or other solid wastes.
- A large variety of wastes and auxiliary fuels may be used.
- Fuel efficiency is high.
- High turndown ratios are obtainable.
- Gas residence times are adequate.

2.2.1.3.3 Disadvantages--

- Normal operating temperatures for multiple hearth incinerators are probably too low for effective thermal destruction of PCBs unless a fired afterburner is used.
- Long solids residence times result in poor temperature response in the incinerator and thus make control of supplementary fuel firing difficult.
- The moving internals in the furnace are subject to damage or clogging from feed solids and corrosion by hydrochloric acid. This leads to high maintenance costs.
- Gas phase mixing is poor.
- PCBs should not be fed at the top of a multiple hearth because rapid volatilization and short residence time could lead to incomplete combustion.

2.2.1.3.4 Facilities and Test Data--Whitmore (38) reported results of incinerating sewage sludge containing about 50 ppm PCBs. Gases exited the furnace at about 615°C after about 0.1 s of residence time. Maximum temperature of ash in the furnace was about 790°C. No PCBs were detected in the ash, so conditions were such that PCBs in the sludge were completely volatilized. However, PCBs were detected in the stack gas. Destruction efficiency was between 91.7% and 97.1%. As noted in the study (38), a possible explantion for the relatively low destruction efficiency was that the PCBs were injected into the sludge cake feed screw which fed the sludge into the top hearth. The temperature in the top hearth was sufficiently high to volatilize completely the PCBs from the sludge, but the residence time was insufficient for complete destruction. Thus, an evaluation of a proposal to burn PCBs in a multiple hearth incinerator should note where it is proposed to inject PCBs. PCBs should preferably be fed into the middle or perhaps, the next-to-bottommost hearth to provide longer residence time.

EPA sponsored tests of incineration of DDT and 2,4,5-T in a prototype unit and on an operating municipal multiple hearth sewage sludge incinerator in Palo Alto, California. Destruction efficiencies for DDT ranged from 99.97% to 99.983% and for 2,4,5-T from 99.99% to 99.996% (39). These compounds are more easily incinerated than PCBs.

As part of a program to develop methods for determining PCB emissions from incinerators and capacitor and transformer filling plants, Haile and Baladi (17) reported on a field test at two municipal sewage sludge incinerators. One test was at the Blue River facility of Kansas City, Missouri, which receives waste with a significant industrial waste component. The second test was at the facility of the City of Mission, Kansas, which receives mostly domestic wastes. The Blue River facility was a four-hearth multiple hearth incinerator. The type at City of Mission was not identified. Operational data, PCB input rates, and destruction efficiencies were not given. PCB emissions from the Blue River facility averaged 375 $\mu g/m^3$, significantly higher than the average of 3.75 $\mu g/m^3$ from the City of Mission facility. Both emission values are as decachlorobiphenyl.

As presently operated, multiple hearth incinerators alone are not suitable for thermal destruction of PCBs.

2.2.1.4 Fluidized Bed--

2.2.1.4.1 Description--A fluidized bed incinerator consists of a refractory-lined cylindrical vessel containing a bed of inert, granular material. Figure 6 is a schematic of a fluidized bed combustor. Air is injected at the bottom of the vessel through a distributor plate at a rate sufficiently high to cause the particles in the bed to act as a theoretical fluid. Passage of the gases through the bed causes strong agitation. Waste gases and liquids are typically injected into or closely above the bed. Sludges and slurries are also injected into or just above the bed. Solids with densities greater than the bed cannot be incinerated in a fluidized bed.

The bed is preheated to startup temperatures by a burner located above and impinging on the bed. The strong agitation of the bed when in operation promotes very rapid and intimate mixing of combustion air and waste. The large mass (relative to the mass of waste) and high heat content of a bed very rapidly raise the waste to combustion temperatures, which in turn transfers heat to the bed.

Gas velocities are typically low, of the order of 0.15 to 0.21 m/sec (9), which gives sufficient residence time. Bed temperatures are restricted to the softening point of the bed material. Sand, a common bed material, limits the temperature to about 1100°C, the point at which sand softens and begins to agglomerate.

Ash from combusted waste either sinks to the bottom of the bed where it is drawn off or passes out through the gas stream outlet. The gaseous effluent stream is conditioned by a scrubber, dry collector, electrostatic precipitator, or a fabric filter.

2.2.1.4.2 Advantages--

- A large surface area results from fluidization of the bed, which contributes to good combustion efficiency.
- Fluctuations in feed rate and composition do not result in violent upsets in incineration temperature because large amounts of heat are stored in the bed.
- Gases, most liquids, and some solids can be incinerated in fluidized beds. Feeds with a high moisture content are easily combusted.
- Long residence times for both gases and solids are achieved.
- The compact design, with no moving parts in the combustion zone, results in low capital costs, and fewer operating problems.

2.2.1.4.3 Disadvantages--

- Maximum combustion temperature is limited by the bed material, which generally cannot tolerate temperatures as high as a refractory lining can.
- Residues are hard to remove from the bed. Thus, metal pieces from shredded capacitors would cause problems.
- Operating costs, especially for power, are high.

2.2.1.4.4 Facilities and Test Data--A fluidized bed unit operated by Systems Technology Corporation (Systech) in Franklin, Ohio, was tested under EPA Contract No. 68-01-2966 (11,40). This unit, Figure 6, has a capacity for up to 1,360 liters per hour of high heat content liquids (>5,560 kcal/kg) and up to 7,570 liters per hour of low heat content liquids (>1,670 kcal/kg). Municipal wastes are burned at a maximum rate of 135 mt/hr. Maximum heat release capability is 15 million kcal/hr. The unit is equipped with a venturi scrubber to control particulate emissions.

Systech's fluidized bed combustor has a refractory-lined steel vessel with an inside diameter of 7.6 meters and a height of 10 meters. The silica bed is 1 meter deep when dry and expands to about 1.8 meters when fluidized.

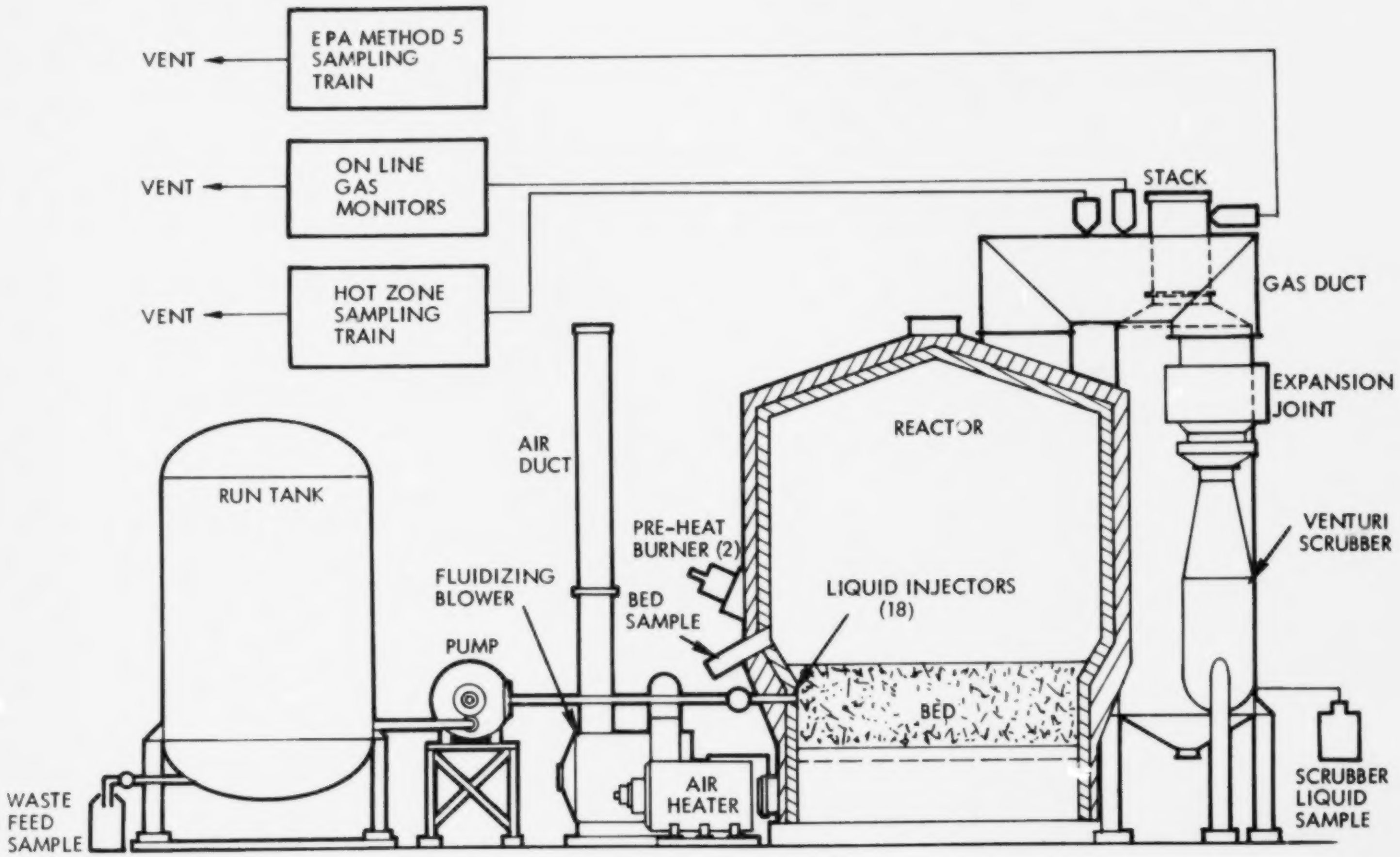

EPA METHOD 5 SAMPLING TRAIN
VENT
ON LINE GAS MONITORS
VENT
HOT ZONE SAMPLING TRAIN
VENT
STACK
GAS DUCT
EXPANSION JOINT
REACTOR
AIR DUCT
RUN TANK
PRE-HEAT BURNER (2)
VENTURI SCRUBBER
FLUIDIZING BLOWER
BED SAMPLE
LIQUID INJECTORS (18)
PUMP
BED
AIR HEATER
WASTE FEED SAMPLE
SCRUBBER LIQUID SAMPLE

Figure 6. Fluidized bed facility schematic (40).

Waste and auxiliary fuel are injected radially into the bed through up to 18 nozzles. Typical bed temperatures range from 600 to 810°C. Further combustion occurs in freeboard volume above the bed where temperatures range up to 980°C. Systech uses a venturi scrubber to control emissions.

Tests were conducted on a phenolic waste from petroleum refining (approximately 86% water) and a methyl methacrylate waste from manufacturing of acrylic plastics. Both were liquids with low heat contents. No PCBs were tested.

Union Oil Company, Union, Maine, is developing (41) and intends to market a fluidized bed combustor. Union Oil's prototype is being used to destroy still bottom residues from its process for recovering used industrial hydrocarbon.

Hazen Research, Inc., of Golden, Colorado, also markets a fluidized bed combustion system (42).

Because of the relatively low temperatures used and the lack of data on PCB destruction, fluidized bed incinerators operated as indicated above cannot be considered a viable option for thermal destruction of PCBs.

2.2.1.5 Multiple Chamber--

2.2.1.5.1 Description--There are three zones in a multiple chamber incinerator: 1) an ignition chamber, 2) a downdraft mixing chamber, and 3) an updraft secondary combustion chamber. Solid waste is fed through charging doors onto grates at the bottom of the ignition chamber, where the waste is dried, volatilized, ignited, and partially oxidized. Incoming waste pushes previously-charged material along the grates toward the ash pit; this comprises the only air/solid mixing in the incinerator.

Multiple chamber incinerators have been used at both municipal and industrial facilities for solid waste disposal. The various configurations are grouped (9) into two general categories: 1) retort type and 2) in-line type.

The retort type (Figure 7) is distinguished by an arrangement of the chambers such that combustion gases are forced to make a 90° change in both horizontal and vertical directions. The primary and secondary combustion chambers share a common wall.

The in-line type (Figure 8) is distinguished by an intermediate secondary combustion-mixing chamber which is followed by a third, secondary combustion chamber. Also, this type is characterized by chamber arrangements that force only vertical direction changes in combustion gas direction.

Retort-type incinerators are considered to have an upper capacity of about 450 kg/hr. In-line type incinerators are not well suited to feed rates below about 340 kg/hr but have upper limits much greater than the rates of typical retort-type installations (9).

Typical multiple chamber incinerators operate at a maximum temperature of about 540°C, which is well below temperatures required for complete destructions of PCBs and most hazardous organic compounds. There is no fundamental reason why these types of incinerators could not be designed with provision for auxiliary fuel feed and more resistant materials of combustion (9). Multiple chamber incinerators cannot handle liquids, slurries, or sludges. They typically handle solids, but could also handle gases. Typical residence times for solids and gases are minutes and seconds, respectively.

2.2.1.5.2 Advantages--

- Technology is proven.
- Gas and solid residence times are adequate for PCB destruction

2.2.1.5.3 Disadvantages--

- Air/waste mixing is inadequate for destruction of PCBs.
- Normal operating temperatures are too low for PCB destruction.
- Labor intensive.

2.2.1.5.4 Facilities and Test Data--Multiple chamber incinerators normally fire municipal solid waste, wood wastes, coal, or other solid wastes. With the addition of auxiliary burners, liquid wastes can be fired. Only one reference to a PCB test at a multiple chamber incinerator was found, and this was not a thermal destruction test but rather was a methods development test. As part of a program to develop methods for determining PCB emissions from incinerators at capacitor and transformer filling plants, Haile and Baladi (17) reported on field tests at five municipal refuse incinerators in the Miami-Ft. Lauderdale, Florida, area: Miami No. 1; Dade

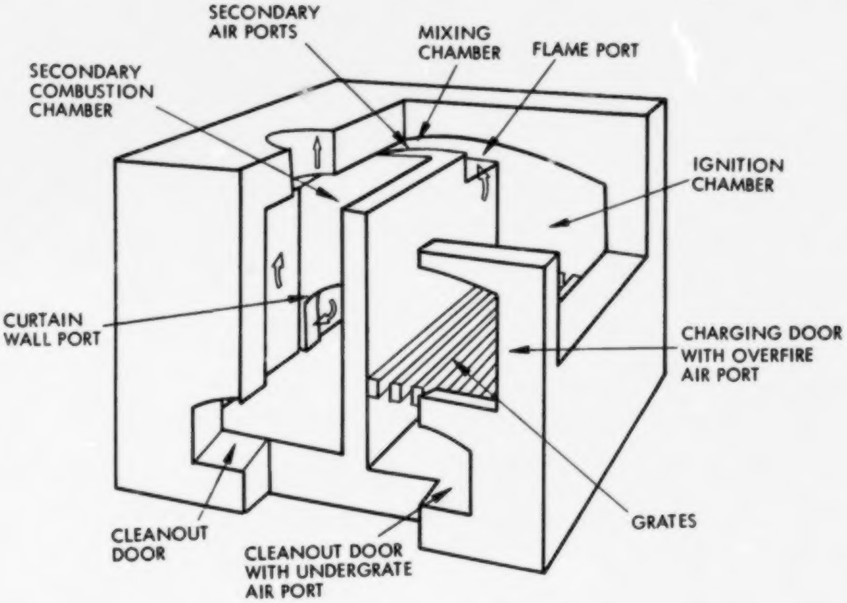

SECONDARY AIR PORTS
MIXING CHAMBER
FLAME PORT
SECONDARY COMBUSTION CHAMBER
IGNITION CHAMBER
CURTAIN WALL PORT
CHARGING DOOR WITH OVERFIRE AIR PORT
GRATES
CLEANOUT DOOR
CLEANOUT DOOR WITH UNDERGRATE AIR PORT

Figure 7. Retort multiple-chamber incinerator (9).

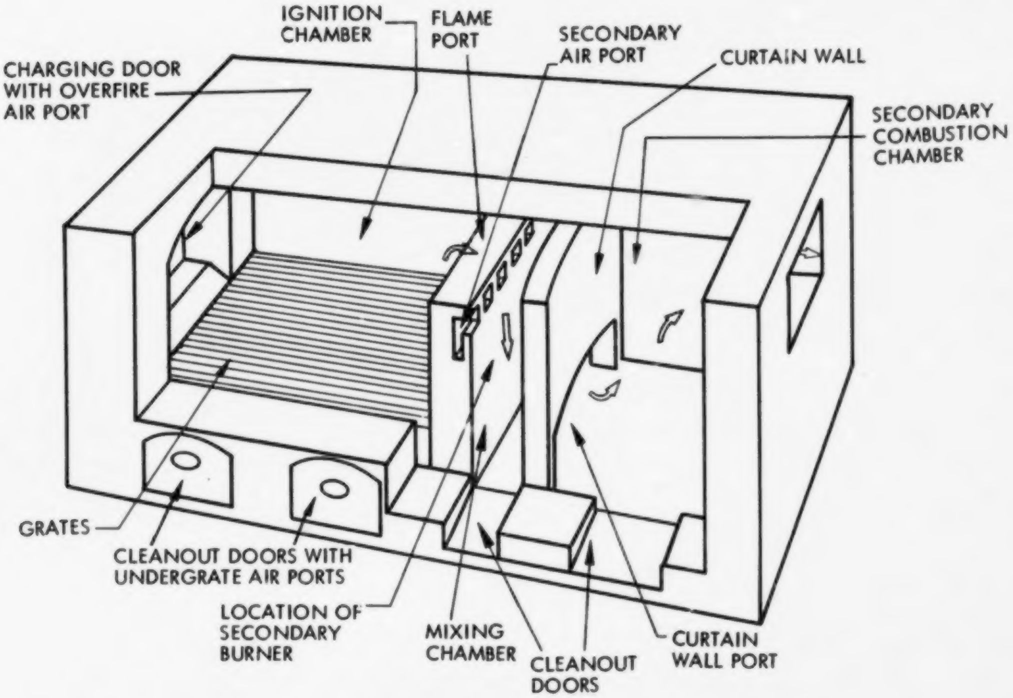

IGNITION CHAMBER
FLAME PORT
SECONDARY AIR PORT
CURTAIN WALL
CHARGING DOOR WITH OVERFIRE AIR PORT
SECONDARY COMBUSTION CHAMBER
GRATES
CLEANOUT DOORS WITH UNDERGRATE AIR PORTS
LOCATION OF SECONDARY BURNER
MIXING CHAMBER
CLEANOUT DOORS
CURTAIN WALL PORT

Figure 8. In-line multiple-chamber incinerator (9).

County, N.E.; Broward County Plant No. 1 (incinerators Nos. 1 and 2); and Broward County Plant No. 4. Incinerator types were not identified, but municipal incinerators are frequently of the multiple chamber type. Operational data, PCB input rates, and destruction efficiencies were not given. Average PCB emissions as $\mu g/m^3$ decachlorobiphenyl were:

- Miami No. 1 - 33.8
- Dade County, N.E. - 10.3
- Broward County Plant No. 1
  - Unit No. 1 - 7.85
  - Unit No. 2 - 5.4
- Broward County Plant No. 4 - 5.5

Other chlorinated organic wastes are being incinerated in small quantities in this type of unit. Some hazardous wastes (not PCBs) have been successfully incinerated in tests conducted by Midwest Research Institute on a pilot-scale modified multiple chamber incinerator (43).

2.2.1.6 Catalytic Combustion--

2.2.1.6.1 Description--Catalytic combustion is most applicable to gaseous wastes containing low concentrations of combustible materials. Preheated gases (320 to 540°C) are passed over a precious metal catalyst supported in the gas stream to expose as much catalyst surface as possible. Combustion occurs in the catalyst bed at temperatures up to about 870°C. A catalytic combustion system is shown schematically in Figure 9.

2.2.1.6.2 Advantages--

- Combustion occurs at a lower temperature than would be necessary for direct flame combustion. Thus, requirements for auxiliary fuel and high temperature refractories are less than for direct flame combustion.
- Combustion product gases produced from catalytic combustion are clean, and well suited for waste-heat recovery.

2.2.1.6.3 Disadvantages--

- High temperatures deactivate most catalysts.
- Catalysts are fouled and poisoned by some impurities in the gas stream. Therefore, the feed to a catalytic combustor must be essentially free of such poisons (e.g., sulfur) or foulants (e.g., particulates).

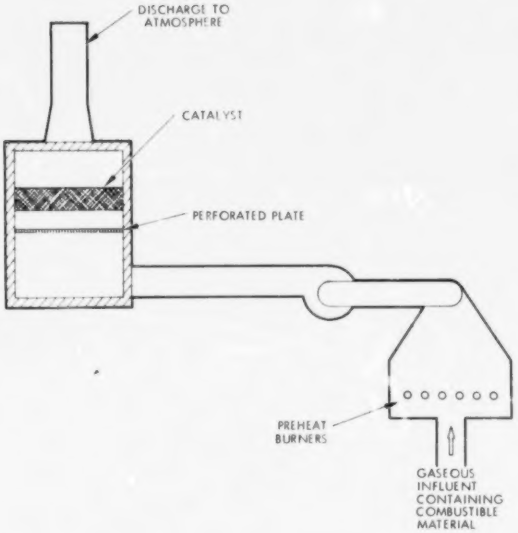

DISCHARGE TO ATMOSPHERE
CATALYST
PERFORATED PLATE
PREHEAT BURNERS
GASEOUS INFLUENT CONTAINING COMBUSTIBLE MATERIAL

Figure 9. Schematic diagram of a catalytic combustor (39).

- Catalytic destruction of PCBs in this type of unit has not been demonstrated.

2.2.1.6.4 Facilities and Test Data--Although it appears that PCB destruction in catalytic combustors has not been investigated, B. F. Goodrich operates a catalytic oxidation process for destruction of other chlorinated hydrocarbon wastes (42). Catalytic combustion may find application in PCB incineration, particularly as a polishing step or as a secondary combustion system for vapor phase PCBs. However, considerable laboratory data must be gathered to support any contention that catalytic combustion can effectively destroy PCBs.

2.2.1.7 Pyrolysis--

2.2.1.7.1 Description--Pyrolysis processes are designed to decompose waste in the absence of oxygen. Often the decomposition products contain gases, liquids, or solids which have a high heating value and can be burned conventionally. Figure 10 is a schematic diagram of a pyrolysis system.

2.2.1.7.2 Advantages--

- Potential for resource recovery.

2.2.1.7.3 Disadvantages--

- Pyrolysis of wastes containing chlorine is not recommended because of the high probability that toxic chlorinated by products will be formed. This is an especially important consideration for PCBs since pyrolysis of these substances produces chlorinated dibenzofurans which are more toxic than PCBs (see Section 2.5).
- Auxiliary equipment for pyrolysis systems tends to be specific for a particular waste feed. Thus pyrolysis systems are usually unable to handle a variety of wastes.

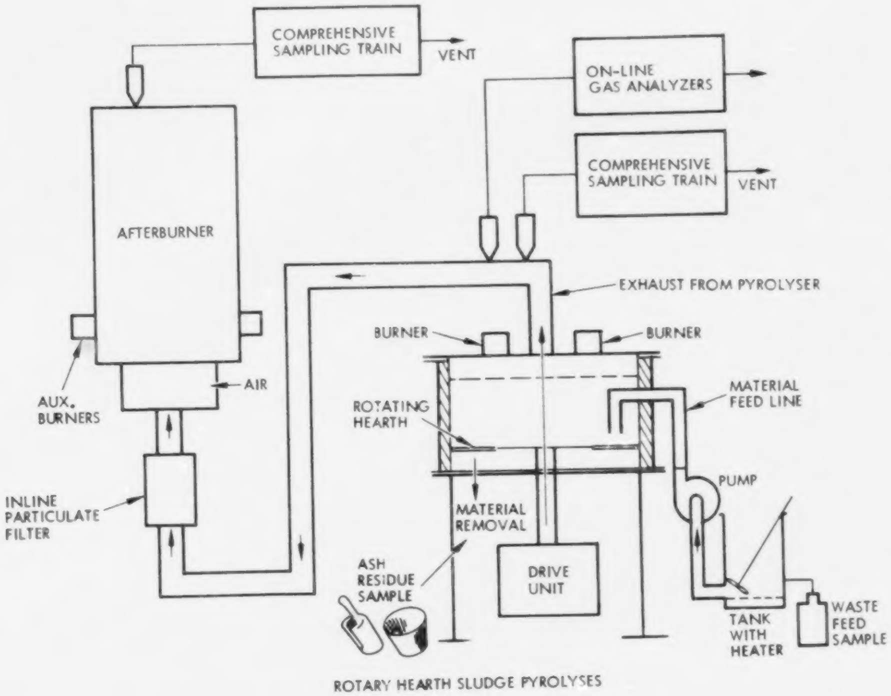

COMPREHENSIVE SAMPLING TRAIN
VENT
ON-LINE GAS ANALYZERS
COMPREHENSIVE SAMPLING TRAIN
VENT
AFTERBURNER
EXHAUST FROM PYROLYSER
BURNER
BURNER
AIR
AUX. BURNERS
ROTATING HEARTH
MATERIAL FEED LINE
PUMP
INLINE PARTICULATE FILTER
MATERIAL REMOVAL
ASH RESIDUE SAMPLE
DRIVE UNIT
TANK WITH HEATER
WASTE FEED SAMPLE
ROTARY HEARTH SLUDGE PYROLYSES

Figure 10. Schematic diagram of a pyrolysis system (42).

2.2.1.7.4 Facilities and Test Data--The Surface Combustion Division of Midland Ross Corporation operates a pyrolytic combustor. This unit was tested (11,44) for disposal of: 1) petroleum refinery wastes (centrifuged API separator bottoms), 2) styrene production wastes, and 3) rubber manufacturing wastes. The products of pyrolysis are a vapor stream and a residual ash or char. The effectiveness of a pyrolysis process is usually evaluated in terms of the vapor stream, which is expected to contain recoverable resources. The ash or char is usually intended for disposal. The average conversions of the organic material in the three waste streams tested at Surface Combustion were:

- API separator bottoms - 70%
- Styrene waste - 60%
- Rubber waste - 80%

The vapor streams from the tests were highly complex. Compounds found ranged from gases of ambient temperature and pressure to high boiling (500°C) liquids and tars, including aromatic compounds.

Given that pyrolytic conditions convert PCBs to polychlorinated dibenzofurans (PCDFs, see Section 2.5), pyrolysis is not recommended as PCB disposal method. Even if the vapor stream were vented into an incinerator or afterburner having a temperature and residence time adequate to ensure complete destruction of residual PCBs and pyrosynthesized PCDFs, the ash or char will be likely to contain PCDFs which would pose a significant disposal problem.

2.2.1.8 Starved Air Combustion--

2.2.1.8.1 Description--Process equipment for starved air combustion is similar to equipment for incinerators (9). However, in starved air combustion, substoichiometric amounts of air are fed. The process is neither purely pyrolytic nor purely oxidative; both types of reactions take place in the system. One application of starved air combustion is shown in Figure 5, in which a multiple hearth reactor is used in the starved air mode. The reactor gasifies the solid or sludge feed, producing a combustible gas which is burned in an afterburner. Air emissions are controlled by a venturi scrubber.

2.2.1.8.2 Advantages--

- Potential for by product recovery.
- High thermal efficiency.

2.2.1.8.3 Disadvantages--

- Not tested on hazardous wastes in general and PCBs in particular
- Use of substoichiometric quantities of oxygen increases the probability of formation of chlorinated dibenzofurans (see Section 2.5).

2.2.1.8.4 Facilities and Test Data--Starved air combustion facilities have not been tested for PCB destruction. Because of the possibility of chlorinated dibenzofuran formation, these units are probably not suitable for PCB destruction.

2.2.1.9 Molten Salt--

2.2.1.9.1 Description--Combustion of waste in this type of incinerator is primarily in a bed of molten alkali metal salts. Air and waste are injected into the bed and are burned at temperatures up to about 980°C. Clean exhaust gas is produced which may not require treatment. Solid residues are trapped in the salt. Reactive salt mixtures may be used which trap chlorides and metals formed from waste destruction. Spent salt is landfilled or regenerated. Figure 11 is a schematic diagram of a molten salt combustor.

2.2.1.9.2 Advantages--

- Particulates and pollutant gases formed during combustion are absorbed or react with salts in the bed so that pollution control requirements are minimal or none.
- Organic wastes are rapidly destroyed at lower temperatures than normally required.
- Residence times of approximately one second are achievable.

2.2.1.9.3 Disadvantages--

- Only pilot-scale units are operational.
- Residue disposal has not been adequately addressed.
- Continuous operation of a molten salt bed is difficult: intermittent operation with frequent bed changes may be required.
- The process is not currently proven reliable technology.

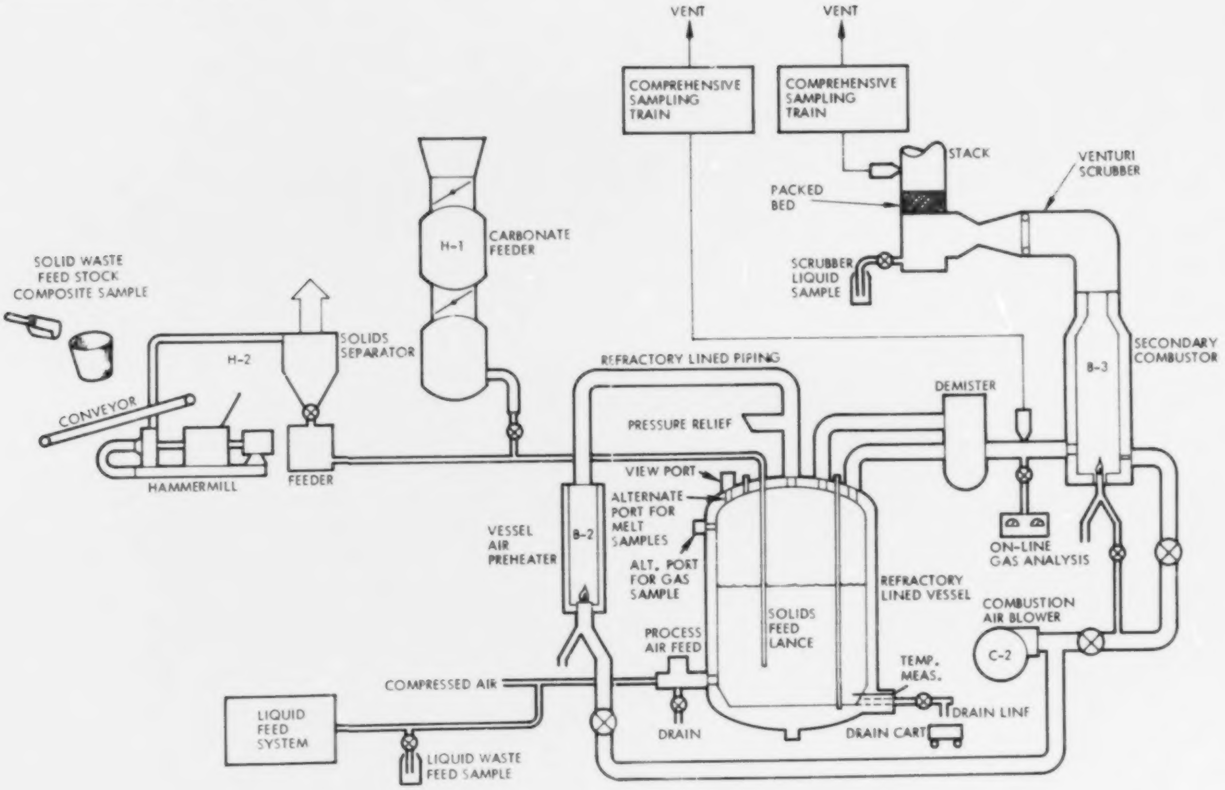

VENT
VENT
COMPREHENSIVE SAMPLING TRAIN
COMPREHENSIVE SAMPLING TRAIN
STACK
VENTURI SCRUBBER
PACKED BED
SCRUBBER LIQUID SAMPLE
CARBONATE FEEDER
H-1
SOLID WASTE FEED STOCK COMPOSITE SAMPLE
SOLIDS SEPARATOR
H-2
CONVEYOR
HAMMERMILL
FEEDER
REFRACTORY LINED PIPING
SECONDARY COMBUSTOR
B-3
DEMISTER
PRESSURE RELIEF
VIEW PORT
ALTERNATE PORT FOR MELT SAMPLES
ALT. PORT FOR GAS SAMPLE
VESSEL AIR PREHEATER
B-2
ON-LINE GAS ANALYSIS
REFRACTORY LINED VESSEL
COMBUSTION AIR BLOWER
C-2
SOLIDS FEED LANCE
PROCESS AIR FEED
TEMP. MEAS.
COMPRESSED AIR
DRAIN LINE
DRAIN
DRAIN CART
LIQUID FEED SYSTEM
LIQUID WASTE FEED SAMPLE

Figure 11. Atomic International Div. molten salt reactor - process flow and sampling schematic (42).

2.2.1.9.4 Facilties and Test Data--The Atomics International Division of Rockwell International built a pilot combustor in 1973 for disposal of chlorinated hydrocarbons, pesticides, and pesticide containers (42). The unit has not been used to dispose of PCBs. Presently, the molten salt process cannot be considered well enough developed for use in PCB incineration.

2.2.1.10 Summary of Incineration Systems--

Table 5 summarizes the potential applicability of various incineration systems to the destruction of liquid and solid PCBs. Several systems have demonstrated applicability: rotary kiln, liquid injection, and multiple hearth (with cautions noted earlier). Other systems have potential applicability but have not been tested or need additional design research: multiple hearth, fluidized bed, and molten salt. Several systems probably have no applicability: catalytic combustion, pyrolysis, and starved air.

TABLE 5. INCINERATION SYSTEM SUMMARY

Type	Applicability	Reasons
Rotary Kiln	Liquids - Yes Solids - Yes	Best system for solid PCB Items. Requires an afterburner.
Liquid Injection	Liquids - Yes Solids - No	Best system for liquid PCBs. May be used as afterburner following a solids incinerator.
Multiple Hearth	Liquids - Yes Solids - Yes	Design is suitable, but may require operation at higher temperatures than currently used. Afterburner may be required.
Fluidized Bed	Liquids - Potential Solids - Potential	Future consideration warranted for liquids. Hard to remove shredded noncombustibles. Temperatures probably too low.
Multiple Chamber	Liquids - Yes Solids - No	Liquids may be suitable if liquid burner is installed above grates. Insufficient air/solid mixing.
Catalytic Combustion	Liquids - No Solids - No	Primarily designed for gases and vapors.
Pyrolysis	Liquids - No Solids - No	High probability of forming toxic combustion products.
Starved Air Combustion	Liquids - No Solids - No	High probability of forming toxic combustion products.
Molten Salt	Liquids - Potential Solids - No	Not proven commercial technology. Temperatures probably too low. Hard to remove shredded noncombustibles. Future consideration warranted for liquids.

Rotary kilns are most suited to destruction of PCB Items. For PCB liquids, the liquid injection incinerator is most suited for thermal destruction. PCB liquids may also be considered for disposal along with PCB solids in most rotary kilns and some multiple hearth furnaces. Incineration of PCB liquids with non-PCB solids can be considered in other incinerator types (e.g., multiple chamber) contingent on a thorough evaluation of system design. In many cases, an afterburner is required to ensure adequate PCB destruction. It should be noted that not all systems designated as potentially applicable for PCB destruction will meet evaluation criteria in Section 4 or qualify as Annex I incinerators.

2.2.2 High Efficiency Boilers

In addition to incinerators, which are designed to combust waste material, conventional boilers can also be used to destroy PCBs if proper combustion conditions are maintained. The largest of these boilers, installed at electric utility and large industrial sites, are designed and instrumented for maximum fuel efficiency. For these units, cofiring PCB liquids and the normal coal, oil, or natural gas fuel represents a viable method for the thermal destruction of PCBs.

Boilers are operated for the basic purpose of supplying a dependable supply of steam for power production or on-site use. Since heat output must be controlled to match demand, these units are not always operated at a constant load.

The key component in the boiler is the burner, normally located in the vertical walls of the furnace. Burners are designed to operate with just enough excess combustion air to burn the fuel completely in order to attain high combustion temperatures and maximum thermal efficiency. The most frequently used burners for gas, oil, and pulverized coal are the circular type, in which combustion air passes through tangentially disposed doors in the air register to provide the turbulence necessary to mix fuel and air. Some burners are dedicated to a specific fuel, while others are capable of firing a mixture of two or more types. Fuel type and load range - the ratio of full load to minimum load at which reliable operation is possible - are two important design features of burners.

2.2.2.1 Gas-Fired Boilers--

2.2.2.1.1 Description--Natural gas is an excellent boiler fuel commonly fired in utility boilers because of its high heating value and clean burning properties. Many industrial boilers fire blast furnace gas, coke oven gas, or refinery gas. Burner designs differ for these different gases due to the different heat release rates and impurities in the various fuels. Excess air requirements range from about 5-10% for most gaseous fuels. Exceptions are blast furnace gas, which requires 15-18% excess air, and multifuel burners requiring 7-12% excess air (45).

2.2.2.1.2 Advantages--

- High flame temperatures are achieved with natural gas firing.
- Mixing characteristics are good.
- Close control of combustion conditions can be maintained.
- Variable-mix multispud type gas elements are available which allow efficient cofiring of natural gas and oil. Switchover from gas to liquid fuels can be accomplished without disruption. This feature would be important if PCB flow had to be cut off.

2.2.2.1.3 Disadvantages--

- Not all gas-fired boilers are equipped to burn liquids.
- No control of hydrogen chloride emissions is provided.
- Higher than normal excess air rates may be required to maintain a constant level of greater than 3% oxygen in the stack. Very high excess air rates may degrade flame stability.

2.2.2.1.4 Facilities and Test Data--Cofiring of PCB liquids with gaseous fuels in boilers has not been attempted.

2.2.2.2 Oil-Fired Boilers--

2.2.2.2.1 Description--Fuel oil burners atomize the liquid fuel into small droplets, exposing a large surface area to combustion air and assuring prompt ignition and rapid combustion. Oil must usually be preheated to reduce its viscosity prior to atomization. Two methods of atomization are used. The most prevalent technique is steam (or air) atomization; mechanical atomizers are used to a lesser extent. Excess air requirements range from 5-10%, normally, but rise to 10-20% for multifuel burners (45).

2.2.2.2.2 Advantages--

- High flame temperatures and good mixing are achieved in large oil-fired boilers.
- Close control of combustion conditions can be maintained.
- Additive systems are often present which could be used to meter PCB flor to the burners. Alternatively, PCBs can be premixed with fuel.

2.2.2.2.3 Disadvantages--

- No control of hydrogen chloride emissions is provided unless a wet scrubber is employed.
- Higher than normal excess air rates may be required to maintain greater than 3% oxygen in the flue gas.

2.2.2.2.4 Facilities and Test Data--Results of PCB burns in an oil-fired boiler have been reported by Florida Power and Light Company (7). The No. 4 boiler at the FP&L Sanford Plant was used in the tests. A fuel additive injection system was used to meter undiluted Askarel (60-100% PCB) into the fuel oil feed to the burners. Feed rates were 34 liters per hour of PCB and 91,200 liters per hour of fuel oil, resulting in a PCB concentration of about 555 ppm in the final feed to the burners.

Accurate measurements of flame temperature and furnace exit temperature were not made, as the boiler was not normally instrumented for these measurements. Normal flame temperatures were estimated at between 1480°C and 1650°C. Residence time was estimated to be 2.7 seconds at 2 percent excess oxygen. Stack testing was conducted only for PCBs and oxygen. Oxygen in the stack gases averaged about 2% during the test burns. PCB samples were taken at the 41 meter level on a 122 meter stack. From 1.8 to 2.0 cubic meters of dry flue gas at standard conditions were collected in hexane. Analyses by gas chromatograph detected no PCBs at a detection limit of 1 ng per 5 μl sample. This equated to a destruction efficiency of greater than 99.9997%. No ash analyses were performed.

Continental Can Company operates a pulp and paper mill at Hopewell, Virginia. In 1976, EPA Region III received information that waste oil supplied to Continental for steam and power generation and rotary lime kiln was contaminated with PCBs (22). Upon confirming that the oil was contaminated, EPA conducted emissions testing. Two of the three oil-fired boilers

(Nos. 2 and 3) were tested.

Boilers Nos. 2 and 3 have design heat input rates of 198 and 391 million Btu per hour, respectively. Process parameters monitored were steam, oil, and feed water integrators; steam, feed water and airflow meters; temperature and pressure gauges on the various process streams, and an oxygen monitor located after the air preheater. The waste oil averaged 5 ppm PCBs. During several tests, the waste oil was spiked with additional PCBs to level of 280 ppm.

Boiler No. 2 temperatures ranged from 1,360 to 1,500°C; boiler No. 3 temperatures ranged from 1,370°C to 1,520°C. Residence times ranged from 2-3 seconds and 3-6 seconds for boilers Nos. 2 and 3, respectively. Boiler No. 2 operated at about 8% excess oxygen, while boiler No. 3 operated between 2-5% excess oxygen. Actual destruction efficiencies, based on PCB emissions, ranged from 99.2% to 99.5% for boiler No. 2 and from 99.1% to 99.9% for boiler No. 3.

General Motors Corporation recently (July 1980) conducted a PCB Trial Burn at its Chevrolet plant in Bay City, Michigan (45,46). No details are available at this time.

2.2.2.3 Coal-Fired Boilers--

2.2.2.3.1 Description--Two methods of firing are possible for coal: suspension firing and fuel-bed firing. Suspension firing predominates for large boilers and is more applicable to destruction of PCB liquids. Either pulverized or crushed coal may be fired in suspension.

The design of furnaces and boilers for coal firing is based on the physical and chemical characteristics of the coal, the steam conditions required, and the emission levels to be met. Coals with high fusion temperatures are suitable for burning, when pulverized, in hopper-bottom furnaces with dry-ash removal. Coals with low fusion temperatures may be burned, when pulverized or crushed, in wet bottom furnaces with slag-tap ash removal. For pulverized dry bottom and wet bottom furnaces, three burner arrangements are used for coal firing: tangential firing, front wall firing, and horizontally opposed firing. These burner arrangements are shown schematically (47) in Figure 12. The vertical firing method, not shown here, is seldom used for utility boilers. Vertical firing furnaces are no longer sold and will not be discussed.

In the tangential firing method, developed by Combustion Engineering, Inc., pulverized coal is introduced from the four corners of the furnace in vertical banks of burner nozzles, and directed towards an imaginary circle in the center of the chamber. Such a firing mechanism results in the formation of a large vortex with its axis on the vertical center line.

In front wall and horizontally opposed fired furnaces, pulverized coal is introduced through a horizontal row of burners mounted normal to the furnace wall(s). For boilers less than 400 MW in size, the burners are typically located on only one wall. For larger boilers, the burners are located on both the front and back walls firing directly opposed to each other. Horizontally opposed fired furnaces are generally newer because of the recent trends towards boilers of larger capacity. The major manufacturers for these furnaces include Babcock and Wilcox Co., Riley Stoker Corp., and Foster Wheeler Energy Corp.

Circular burners are most often used for pulverized coal firing. From 15-20% excess air is normally required.

In cyclone fired furnaces, the coal is not pulverized but is crushed to 4-mesh size, and admitted with the primary air in a tangential fashion to a horizaontal, cylindrical chamber (Figure 13). The finer coal particles are burned in suspension, while the coarser ones are thrown to the walls by centrifugal force. The wall surface, having a coating of molten slag, retains most of the coal particles until they are burned. The cyclone furnace was developed by Babcock and Wilcox Co.

Cyclone furnaces may be designed to cofire oil or natural gas. Oil burners can be installed to inject fluid into the secondary air stream or along the axis of the cyclone. Excess air requirements are about 10-15%.

2.2.2.3.2 Advantages--

- Both pulverized coal burners and cyclone furnaces can be equipped to cofire oil.
- Hydrogen chloride emissions can be controlled with wet scrubbers already installed at many plants.
- High temperatures are achieved and close control of combustion can be maintained.

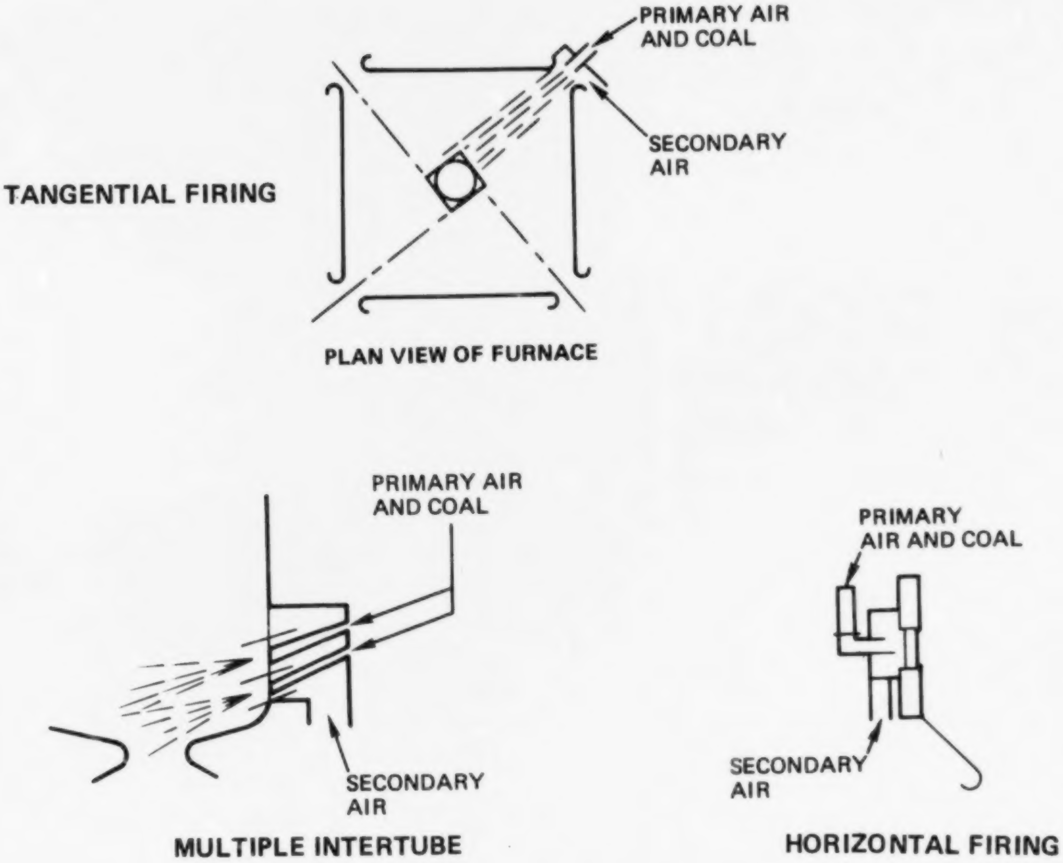

PRIMARY AIR AND COAL
SECONDARY AIR
TANGENTIAL FIRING
PLAN VIEW OF FURNACE
PRIMARY AIR AND COAL
SECONDARY AIR
MULTIPLE INTERTUBE
PRIMARY AIR AND COAL
SECONDARY AIR
HORIZONTAL FIRING

Figure 12. Pulverized coal firing methods (47).

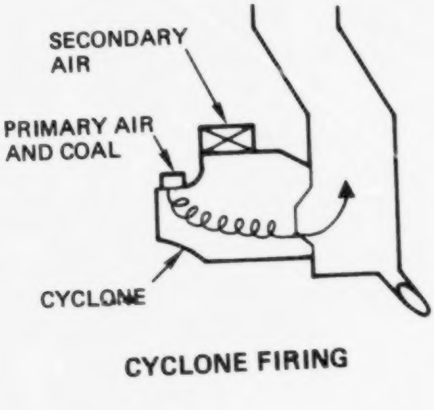

SECONDARY AIR
PRIMARY AIR AND COAL
CYCLONE
CYCLONE FIRING

Figure 13. Cyclone firing of crushed coal (47).

2.2.2.3.3 Disadvantages--

- Cofiring of pulverized coal and oil in circular burners for long periods of time may cause coke formation on the pulverized coal element.
- Instrumentation necessary to monitor certain combustion parameters may not be installed.

2.2.2.3.4 Facilities and Test Data--Only one reference to a PCB destruction test in a coal-fired boiler was found (48). This was a test in lieu of a normal Trial Burn conducted in accordance with the PCB Regulations at Tennessee Eastman Company's Kingsport, Tennessee plant. Power boilers Nos. 23 and 24 were tested. These units are coal-fired and rated nominally at 425 million Btu/hr each, well above the regulatory requirement of at least 50 million Btu/hr. Neither the weight nor volume of coal could be accurately determined. The waste was essentially toluene contaminated with about 400 ppm PCBs. The nominal waste feed rate (based on 10% of the boilers' rated capacities and normal operating loads) was 19 liters per minute. Normal oxygen content of the stack gas was 8.5%.

Tests were conducted on November 5-9, 1979. CO, CO_2, and O_2 were monitored. The waste feed rate averaged 13 liters per minute; the PCB concentration averaged 336 ppm, thus the PCB feed rate was about 4.1 grams/min. CO averaged 39 ppm, CO_2 averaged 12.4%, and O_2 averaged 5.9%. Combustion temperatures and residence times were not given. Traces of PCBs were detected in the blank and in samples from three of the four tests. Destruction efficiencies ranged from >99.7% (no PCBs detected but high levels of interferences) to 99.993%.

2.2.3 Summary

Table 6 summarizes the thermal destruction testing located in the literature. It can be seen that thermal destruction of PCBs in incinerators (rotary kiln and liquid injection) and high efficiency can be effected in accordance with the PCB Regulations.

2.3 SAMPLING AND ANALYSIS METHODOLOGIES FOR PCBs

This section presents results of a literature search on methodologies for sampling and analysis for PCBs in combustion source stacks, ambient air, work space air, liquids, and solids. Recommended methods are described.

TABLE 6. SUMMARY OF PCB THERMAL DESTRUCTION TESTS

Unit Type	Owner/Operator	Feedstock	Date	Trial Burn	Destruction Efficiency, %
Rotary kiln/ liquid injection	Rollins Environmental Services	Whole PCB capacitors	1976	No	>99.999[a]
		Hammermilled PCB capacitors	1976	No	99.5 [a]
		Liquid PCBs	1979	Yes	99.99997[b]
	Energy Systems Company	Liquid PCBs and Shredded PCB capacitors	1979	Yes	>99.9999[b]
Cement kiln	St. Lawrence Cement Co.	Liquid PCBs	1976	No	99.986[a,c]
	Peerless Cement Co.	Liquid PCBs	1976	No	99.983[a]
Liquid injection	General Electric Co.	PCB waste oil	1974	No	99.9921-99.9995
Multiple hearth	Palo Alto, CA.	Liquid PCBs	1975	No	91.7-97.1[a]
High efficiency boiler	Florida Power & Light	Liquid PCBs, oil	1974	No	>99.9997[a]
	Continental Can Co.	Liquid PCBs, oil	1976	No	99.1-99.9[a]
	General Motors Co.	Liquid PCBs, oil	1980	Yes	Not available
	Tennessee Eastman Co.	Liquid PCBs, coal	1979	Yes	>99.7-99.993[b]

a. Overall DE, all effluent streams
b. Gas phase DC only
c. Inferred from test report

2.3.1 Sampling Methodologies

A critical factor in all sampling activities is obtaining a representative sample, for the accuracy and precision of the analytical result can be no greater than the accuracy and precision of the sampling. EPA (49) has specified in detail (Method 5) how to obtain representative samples of particulate and gases in stacks and ducts. Many of the sampling methods described in this Section are based on modified Method 5 sampling trains. Grant (50) and "Standard Methods" (51) describe methods for sampling aqueous streams. The American society for Testing Materials (52) gives a procedure for obtaining representative samples of bulk solids. EPA has recently published a manual for sampling and analysis of RCRA hazardous materials (53).

Sampling methodologies described below emphasize sampling stacks and aqueous and solid process streams. Ambient air monitoring is also discussed; however, the likelihood of detectable amounts of PCBs being emitted from a properly designed and controlled incinerator or boiler is considered extremely low.

2.3.1.1 Stack Sampling--

Methods of sampling gases (stack or ambient air) can be grouped into three general categories: 1) liquid absorption systems, 2) liquid phase absorbents coated on solid supports, and 3) solid adsorbents. Liquid absorption systems typically involve some type of impinger or fritted gas bubbler and a vacuum pump. A widely used configuration consists of Greenburg-Smith impingers and a vacuum pump drawing gas at rates from about 10 to 30 lpm. Impinger contents vary widely. When fritted gas bubblers are used, particulate matter can lodge in and plug the frits.

Solid adsorbent systems involve the use of granular solids which trap organic vapors by means of adsorption. Types of granular solids that have been used for PCB sampling include porous polymers (e.g., XAD-2 and TENAX-GC), polyurethane foam, and Florisil. A vacuum pump is used to pull gas through the adsorbent, and flow rates can be much higher than in liquid absorption or liquid phase on solid support systems. Solid adsorbent systems have the advantage that there is no liquid phase which can interfere in analysis of trapped compounds, but the organic adsorbents generally produce their own background. Solid adsorbents typically must be "cleaned" prior to use to reduce the background, and the residual background must be accounted for in analysis. Care must be taken when packing granular adsorbents so that channeling (channels of lower packing density which allow faster than average gas flow) does not occur. Also, solid adsorbents all have finite capacity for organic compounds, and test conditions (gas flow, bed temperature, sampling time) must be such that the capacity is not exceeded.

Solid adsorbent sampling systems offer numerous advantages over liquid absorbtion and liquid phase on solid support systems, and they have been much more widely used over the last few years for sampling stack gas and ambient air. Consequently, uses of solid adsorbent sampling systems are described in greater detail in subsequent sections.

Condensation in cold traps has been used in organic vapor sampling, but this technique has a fundamental physicochemical limitation for sampling trace compounds. If the partial pressure (concentration) of the sought-for species in the stream being sampled is equal to or lower than its saturation vapor pressure at the temperature of the trap, then the species cannot be trapped. Further, when the saturation vapor pressure at trap temperature of the sought-for species is a significant fraction of the gas phase partial pressure of the sought-for species, trapping is not quantitative.

There are two major systems for sampling combustion zone gases. The first is typified by the EPA Method 5 train (49) which is the standard system for determining particulate mass emissions. The Method 5 train, shown schematically in Figure 14, consists of a heated probe, a particulate filter in an oven maintained at stack temperature, and a series of impingers. One or more of the impingers contains a liquid to absorb vapors, one is usually empty, and one contains silica gel to absorb moisture. A pump and a dry gas meter complete this train. It is operated isokinetically, usually at about 28 lpm (1 cfm). The Method 5 train is constructed of glass. Therefore, it is suitable for sampling combustion zone gases containing HCl.

Modifications of the standard Method 5 train for sampling PCBs (and other organic or organochlorine compounds) include: 1) insertion of a water-cooled sorbent trap (e.g., XAD-2, TENAX-GC, etc.) between the filter and first impinger; 2) insertion of a trap containing Florisil between the last two impingers, or altering impinger contents to improve trapping efficiency. Each of these modifications has been developed, tested, and used for sampling combustion gases for PCBs, as well as other organic compounds. Each is described in subsequent paragraphs.

The second major system is typified by the Source Assessment Sampling System (SASS) developed (54) under the cognizance of EPA's Industrial Environmental Research Laboratory, Research Triangle Park (IERL-RTP). This train is mandated (55,56) for use in source characterization and emissions assessment programs sponsored by IERL-RTP. This train apparently has not been used for PCB sampling. However, its high volume capability would be useful in situations where PCB emissions would be expected to be too low for modified Method 5 trains to acquire samples of adequate size.

The SASS train, shown schematically in Figure 15, consists of a heated probe, three cyclones and a filter in a heated oven for sizing particulates into four ranges, an organic vapor sorbent trap containing XAD-2 resin which is cooled to 20°C, a drainable condensate trap, a series of four impingers

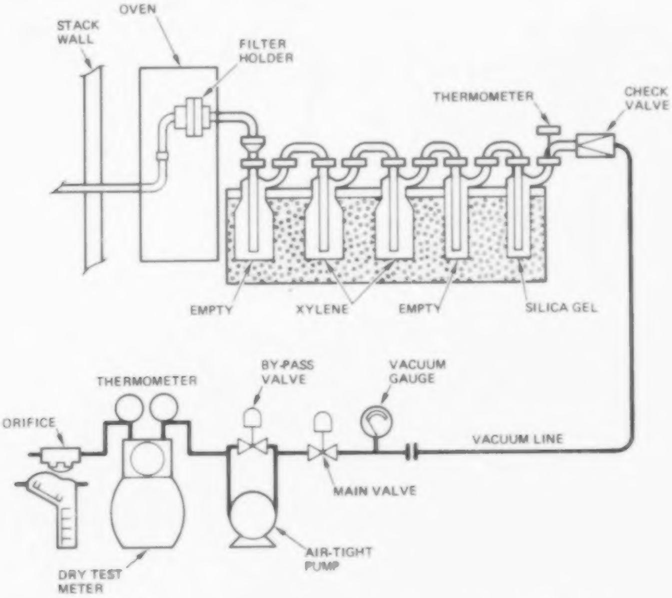

STACK WALL
OVEN
FILTER HOLDER
THERMOMETER
CHECK VALVE
EMPTY
XYLENE
EMPTY
SILICA GEL
THERMOMETER
BY-PASS VALVE
VACUUM GAUGE
ORIFICE
VACUUM LINE
MAIN VALVE
AIR-TIGHT PUMP
DRY TEST METER

Figure 14. Schematic of EPA Method 5 train.

(two which trap volatile metallic and sulfur species, one of which is empty, and the last of which contains silica gel), a pump, and a dry gas meter. The SASS train is operated isokinetically from 4 to 5 cfm (112-140 lpm), and a 30 m^3 sample is usually required (55,56). The SASS train is constructed of glass and stainless steel. In particular, the XAD-2 module, in which the stack gas is cooled to 20°C to promote more efficient sorption of organics, is made of stainless steel (Type 316) which is corroded by aqueous HCl. Glass XAD-2 modules are not commercially available. The use of the SASS train thus has limited capability for sampling HCl-laden streams. There is only one datum available on maximum allowable HCl content. The SASS train was used (32) during a test on the M/T Vulcanus. The sorbent module was rapidly and seriously corroded by the combustion effluent which contained approximately 80 g/m^3 of HCl.

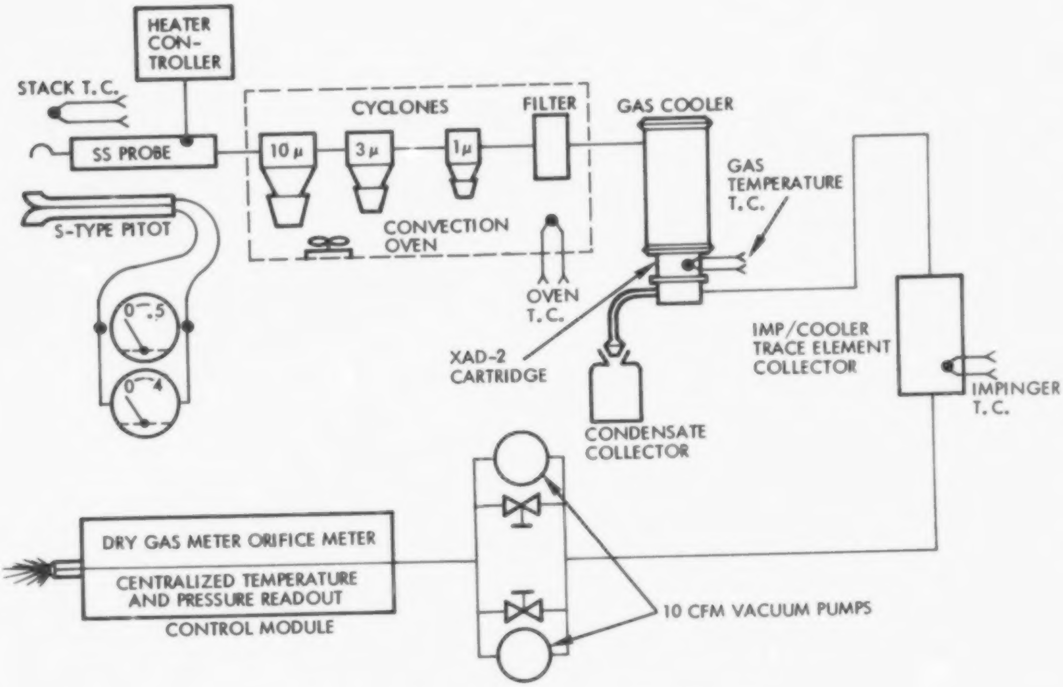

HEATER CON-TROLLER
STACK T.C.
SS PROBE
S-TYPE PITOT
CYCLONES
10 μ
3 μ
1 μ
FILTER
CONVECTION OVEN
OVEN T.C.
GAS COOLER
GAS TEMPERATURE T.C.
XAD-2 CARTRIDGE
CONDENSATE COLLECTOR
IMP/COOLER TRACE ELEMENT COLLECTOR
IMPINGER T.C.
DRY GAS METER ORIFICE METER
CENTRALIZED TEMPERATURE AND PRESSURE READOUT
CONTROL MODULE
10 CFM VACUUM PUMPS

Figure 15. SASS train schematic.

2.3.1.1.1 Liquid absorption systems--EPA (22) reported on PCB emissions testing at a pulp and paper mill which had been supplied with PCB-contaminated waste oil used for firing its boilers. Sampling and analysis of the oil confirmed PCB contamination. Two boilers and a lime kiln were tested for PCB emissions. Stack sampling was performed with a Method 5 train with xylene-filled impingers. Ducts were traversed, and the sampling rate was between 90% and 110% of isokinetic.

The DDT/PCB incineration tests conducted by EPA Region I at General Electric Company's Pittsfield, Massachusetts liquid injection incinerator utilized a modified Method 5 train employing three ethylene glycol filled impingers and isokinetic sampling (27).

In their study of incinerator operating conditions for pesticide disposal, Ferguson, et al. (43) used the following methods. The train for sampling the gaseous effluent consisted of: 1) a glass probe; 2) three midget impingers; 3) an 0.8 μm filter; 4) a critical orifice; 5) a liquid nitrogen cooled trap; 6) a pump; and 7) a rotameter. A variety of liquids were used to fill the first two impingers, depending on the pesticide being tested. Flow rates were of the order of 0.5 lpm, sample periods were about 0.5 hours. When solid pesticides were incinerated, a Method 5 train was used in order to measure particulate pesticide emissions. Procedures for obtaining representative samples of solid residues and scrubber liquids were also described.

Guilford and Brandon (57) reported on a pilot scale PCB waste destruction study. Both liquid and solid (capacitors) waste PCBs were tested. Combustion gas samples from the inlet and outlet to the secondary combustion chamber were pulled through two ethylene glycol filled impingers in series which were immersed in a water-ice bath. A stainless steel probe, manometer, dry gas meter, and a pump completed the system, which can be viewed as a Method 5, modified by excluding the filter and changing the impinger contents. They determined that each impinger had a trapping efficiency of 94% and that two in series had a combined efficiency of 99.64%. The sampling flow rate was not specified, but the maximum allowable leak was specified as 0.06 lpm.

Guilford and Rosenblatt reported (58) on PCB emissions in Ontario from: 1) three PCB capacitor manufacturers, 2) two municipal sewage sludge incinerators, and 3) two municipal refuse incinerators. These were not destruction efficiency tests. A conventional Method 5 train with ethylene glycol filled impingers was used to sample stacks from the incinerators. Samples of scrubber water and sludge were also taken. When the moisture content was high, the first impinger was left empty. Sampling rates were about 20 lpm (0.7 cfm) and within ± 10% of isokinetic. The system was tested in the laboratory before field use by passing Aroclor mixtures at known air concentrations through the train. Capture efficiency was 97.7% which was considered to be satisfactory.

Komaniya, et al. (59) reported on a laboratory scale test of incineration of PCBs. They sampled combustion zone gases by pumping through three impingers, the first filled with water and the second two filled with hexane. Sample volumes of 30 liters at 1 lpm were taken.

2.3.1.1.2 Liquid absorbents on solid supports--No studies of thermal destruction of PCBs using liquid absorbents on solid supports were found.

2.3.1.1.3 Solid adsorbents--Ackerman, et al. (11,12) reported on an incineration test of whole PCB-containing capacitors and hammermilled PCB-containing capacitors at a commercial chemical waste incineration facility. Both PCB materials were incinerated in a rotary kiln incinerator. A baseline test with No. 2 fuel oil was also performed. Combustion zone, stack gas, waste, and scrubber water samples were taken. Combustion zone samples were taken with a Method 5 train modified with a water-cooled sorbent trap containing XAD-2 resin. Flow rates were approximately 30 lpm (1.1 cfm) for 2 hours. Leak rates were less than 0.6 lpm. The incinerator stack was sampled with a standard Method 5 train for particulate loading. Figure 16 is a schematic of the train used in these tests.

MacDonald, et al. (20) reported on thermal destruction testing of PCBs in a cement kiln. In cooperation with Environment Canada, U.S. EPA supplemented the Canadian studies through participating in analyses of samples taken during the tests. Stack sampling at the cement plant was performed with a standard Method 5 train for particulates and a low flow rate train containing a Chromosorb 102 sorbent trap for organic compounds. Samples

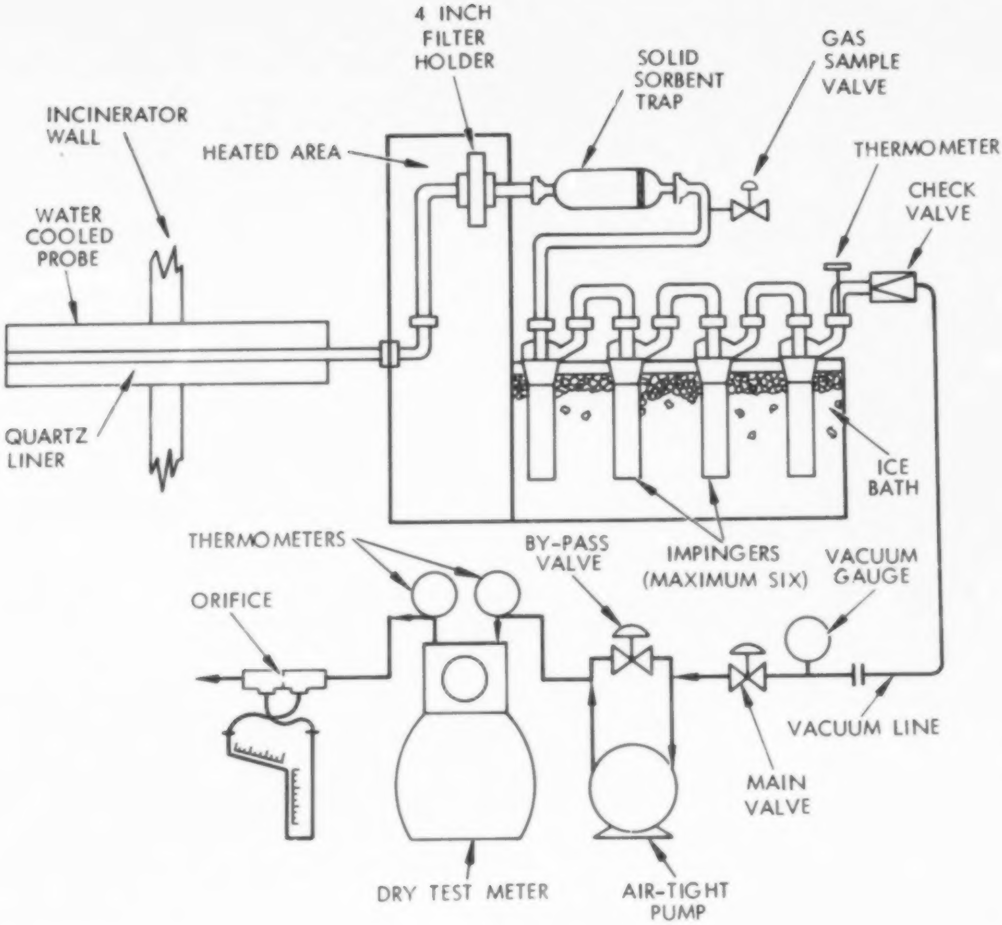

4 INCH FILTER HOLDER
SOLID SORBENT TRAP
GAS SAMPLE VALVE
INCINERATOR WALL
HEATED AREA
THERMOMETER
CHECK VALVE
WATER COOLED PROBE
QUARTZ LINER
ICE BATH
THERMOMETERS
BY-PASS VALVE
IMPINGERS (MAXIMUM SIX)
VACUUM GAUGE
ORIFICE
VACUUM LINE
MAIN VALVE
DRY TEST METER
AIR-TIGHT PUMP

Figure 16. Schematic of modified Method 5 stack sampling train.

were also taken of a clinker product, clinker fines, electrostatic precipitator dusts, and cement mixutres.

Haile and Baladi (17) developed and validated a method proposed by EPA for measuring PCB emissions from incinerators and capacitor- and transformer-filling plants. The proposed method involved collecting PCBs in a train consisting of a filter followed by a solid sorbent and converting trapped PCBs to decachlorobiphenyl (DCB). Sorbents evaluated were: Florisil, XAD-2, and Tenax GC. All were cleaned by soxhlet extraction. Florisil was then activated at 650°C. Their studies showed that Florisil was [illegible]rable to XAD-2 and Tenax GC because of generally higher and more reproducible trapping-recovery efficiencies and lower levels of extracted contaminants. Later in the study, specially cleaned XAD-2 was shown to have an acceptable background.

Haile and Baladi (17) tested their PCB sampling and analysis method at two municipal sewage sludge incinerators and two commercial industrial waste incinerators. Figure 17 shows the sampling train used. The first two impingers contained water, the third was empty, the fourth contained 10% NaOH, and the fifth contained indicating silica gel. An organic vapor sorbent trap containing Florisil was placed between the fourth and fifth impingers. Sampling was conducted according to Method 5 and was within 10% of isokinetic. This is the train recommended by EPA's interim sampling and analysis manual (60).

As a support document and interim policy guideline to the PCB Regulations, EPA published (60) an interim sampling and analysis manual for PCB disposal. The authors recommend that samples for analysis of PCBs and other chlorinated and unchlorinated organics be collected on a solid sorbent trap, such as XAD-2. (XAD-2 is perhaps the best-characterized of all porous polymer sorbents. References 61-63 and references therein describe characterization studies.) Tenax-GC has also been widely studied, References 61-64. This trap is typically located downstream of the heated filter and upstream of the first impinger. The trap temperature must be kept constant and low (but above the freezing point of water) because the retention of sorbed species is higher at lower trap temperatures (i.e., logarithm of retention volume is proportional to reciprocal temperature). Figure 16 is a schematic of such a train (filter and housing not shown) taken from

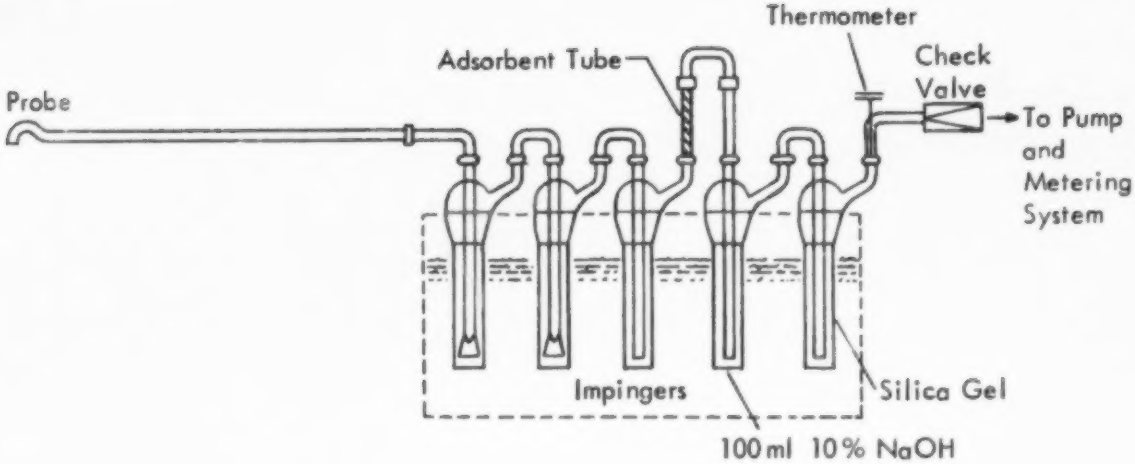


Figure 17. Preferred PCB sampling train configuration (17).

Reference 33. This type of train has been extensively used for testing combustion sources (11,32,34).

While the text of EPA's interim manual (60) recommends use of a Method 5 train modified with an XAD-2 sorbent trap, Attachment E of the manual specifies using a Method 5 train modified with a Florisil adsorbent trap placed between the third and fourth impingers. Figure 17 is a schematic of this train.

A PCB Trial Burn was recently (November 1979) performed by Rollins Environmental Services, Inc., Deer Park, TX (13,14). The sampling train used for these tests was a modified Method 5: 1) heated probe, 2) no filter, 3) two water filled impingers, 4) an empty impinger, 5) a Florisil sorbent trap, 6) a backup sorbent trap containing XAD-2, and 7) a silica gel filled impinger. Sampling was conducted isokinetically by Method 5 procedures. Samples of all process input and output streams were taken.

The Electric Power Research Institute recently (October 1979) sponsored a PCB Trial Burn test at Energy Systems Company, El Dorado, AK (15, 16). Combustion gas samples were taken with a modified Method 5 train: 1) heated probe, 2) no filter, 3) two water filled impingers, 4) one empty impinger, 5) a Florisil sorbent trap, 6) a backup XAD-2 trap, and 7) a silica gel impinger. Sampling was performed isokinetically by Method 5 procedures. Samples of all process input and output streams were taken. Ambient air samples were also taken at several locations during the tests. These samplers used polyurethane foam to collect PCBs and were modified and operated by the method proposed by Stratton, et al. (65).

Tennessee Eastman Company recently (November 1979) performed a PCB Trial Burn in a coal-fired high efficiency power boiler (48). One test was performed on each of four days. The sampling train was a modified Method 5: 1) heated probe, 2) cyclone, 3) two water filled impingers, 4) one empty impinger, 5) Florisil trap, 6) silica gel filled impinger. Because the combustion gas samples were taken at the boiler outlet before the mechanical dust collector and because high particulate loadings were expected at this location, a cyclone was substituted for the filter. Sampling was conducted isokinetically by Method 5 procedures.

General Motors recently conducted (July 1980) a PCB Trial Burn at its Chevrolet plant in Bay City, Michigan (45,46). The train was a modified Method 5: 1) heated probe, 2) no filter, 3) two water filled impingers; 4) one empty impinger, 5) Florisil trap, and 6) silica gel filled impinger. Sampling was conducted isokinetically by Method 5 procedures.

2.3.1.1.4 Recommended sampling methods--It is recommended that the Florisil trap modified Method 5 train described by Beard and Schaum in EPA's Interim Sampling and Analysis Manual be used for sampling PCBs in stack gas emissions from Annex I incinerators and high efficiency boilers. The method has been used for four recent PCB Trial Burns (13-16,45,46,48). The train is operated according to Method 5, and a detailed procedure is given in (60). If particulate matter loading is expected to be high, a cyclone may be incorporated before the filter to reduce the number of filter changes during a verification test.

It is recommended that an XAD-2 trap modified Method 5 train be used for sampling for RCls and other organic compounds when testing an Annex I incinerator. As described previously, XAD-2 resin has been extensively tested for retention of organic compounds (60-62) and widely used for combustion source testing (11,61-63). A primary advantage of XAD-2 is its greater capacity for organic compounds than Florisil.

Additional work on PCB trapping efficiency and recovery on Florisil should be performed. The report of Haile and Baladi (17) showed that the recovery of a dichlorobiphenyl isomer was only 47% under the following conditions: 1) 4 hour sampling, 2) ambient temperature, 3) 20 lpm (0.7 cfm), and 4) trap size 150 mm long, 22 mm diameter, and 7.5 g of Florisil. These conditions are essentially those required by Attachment E of EPA's Interim Manual (59) and used in the four PCB Trial Burns cited above. It is widely recognized that combustion and environmental aging (e.g., weathering and photolysis) dechlorinate more highly chlorinated biphenyls to ones with lower degrees of chlorination. Thus, the recommended sampling system lacks adequate trapping efficiency for those chlorobiphenyls (mono- and di-chlorobiphenyls) that ought to be enhanced by incineration.

2.3.1.2 Ambient Air Sampling--

As described in Section 2.3.1.1, methods of ambient air sampling for PCBs fall into three general categories: 1) liquid absorption systems, 2) liquid phase absorbents on solid supports, and 3) solid adsorbents. Each method as applied to ambient air sampling is described in subsequent sections.

2.3.1.2.1 Liquid absorption systems--A widely used configuration consists of Greenburg-Smith impingers, a vacuum pump drawing air at rates from about 10 to 30 lpm through ethylene glycol. Trapping solutions in the impingers vary. This method has been used by EPA (66), Kutz and Yang (67), Enos, et al, (68), and Staiff, et al. (69). Stanley, et al. (70) used hexylene glycol; Leighton and Feldman (27) and Hocheiser (71) used hexane; American National Standards Institute used toluene (72), and the American Industrial Hygiene Association (73) used secondary butyl alcohol as trapping media. When fritted gas bubblers are used, particulate material lodges in the frit, and PCBs adsorbed on the particulates are extracted by the trapping medium. The frits are generally rinsed along with the impingers during sample recovery.

2.3.1.2.2 Liquid phase on solid supports--As described in Section 2.3.1.1, there are two types of liquid phase on solid support systems, one of which is designed to serve as an alternative to liquid absorption systems. Compton and Bjorkland (74) used cottonseed oil on 3 mm glass beads; Harvy and

Steinhauer (75,76) used a mixture of 0.25 percent OV-17 and silicone oil coated on 64 mm ceramic saddles; Wakimoto, et al. (77) used 5% glycerine coated on Florisil; and Seiber, et al. (78) used 5% paraffin oil coated on Chromosorb A. The work of Harvey and Steinhauer (75,76) and of Wakimoto, et al. (77) was specifically directed at PCBs; the other workers were sampling for pesticides in general.

Static systems have been used for trapping PCBs and pesticides. Risebrough, et al. (79) used 30% glycerine in water to coat 0.5 mm nylon net. Tessori and Spencer (80) used 10% ethylene glycol in acetone to coat nylon net. Sodergren (81) used SE-30 silicone oil to coat 0.2 mm nylon net. Staiff, et al. (67) used ethylene glycol treated nylon net. Young, et al. (82) treated glass plates with mineral oil.

Young, et al. (82) showed that, upon prolonged exposure, collection efficiency of static systems declined, indicating volatilization of trapped PCBs. They also found that volatility losses were greatest for lower molecular weight PCBs, which are the PCBs generally present in air in the greatest concentration.

2.3.1.2.3 Solid adsorbents--A number of solid adsorbent systems have been tested for PCB sampling. These systems allow greater flow rates than liquid phase or solid support systems. Because they are more popular, literature on these systems is described in greater detail than that on liquid absorption or liquid phase or solid supports.

Giam, et al. (83) collected PCBs in air by using columns packed with Florisil and anhydrous sodium sulfate. Air was sampled at 4 lpm for up to 60 hours. Burg, et al. (84) sampled ambient air in Ontario for PCBs using a Method 5 train modified with a Tenax-GC sorbent trap.

Bidelman and Olney (85) devised a high volume sampling system employing polyurethane foam as a collection medium. Cylindrical polyurethane foam plugs, 10 cm thick, were placed behind the filter holder in a standard high volume air sampler. Air was sampled between 0.5 and 1.0 m^3/min (14-28 cfm). The authors evaluated the collection efficiency of the system. They found that less than 1% of the test PCBs were retained on the filter and that 96 to 99% of the total collected was on the first polyurethane foam plug. At the same time, they also tested the collection efficiency of

Greenburg-Smith impinger systems charged with ethylene glycol. They found that the impinger system trapped from 75 to 82% of tetra- and pentachlorobiphenyl test compounds. Bidelman and Olney (86) used this system to measure PCBs in the atmosphere over the Sargasso Sea near Mermuda and in Rhode Island. Air was sampled at a rate of 0.4 to 0.8 m^3/min (14-28 cfm).

Several other workers have also used polyurethane foam as a collection medium: Rhodes, et al. (87), Rice, et al. (88), and Lewis, et al. (89).

Stratton, et al. (65) reported on an extensive methods development study on sampling PCBs in ambient air. They used the system developed by Bidelman and Olney (85) as a starting point and modified it to improve its performance. Figure 18 shows this system schematically. The authors describe the modifications made, the laboratory tests performed to verify the method, and field testing. They also describe the extensive polyurethane foam cleanup procedure necessary before it can be used for sampling.

Validation studies performed by Stratton, et al. (65) indicated that each PCB isomer has a different retention time in polyurethane foam. Retention times are generally in order of decreasing volatility. Thus, monochlorobiphenyl is the least retained PCB species. They found maximum sampling period to be about 2 hours at 0.7 m^3/min (84 m^3 or 3000 ft^3). The authors' conclusions were:

- Collection and recovery efficiencies are independent of flow rate in the range of 0.6 to 1.0 m^3/min (21-28 cfm).
- Ambient temperature and humidity have no effect on collection efficiency.
- Breakthrough or loss of PCB isomers occurs in the order monochlorobiphenyl, dichlorobiphenyl, and higher substituted species.
- Quantitative collection (85%) is assured when the sampling period does not exceed 2 hours.
- The mean collection efficiency for all tests conducted with Aroclors 1016 and 1242 was 101 ± 10%.

The authors conducted several field tests of the system. Urban ambient air in Jacksonville, FL, was sampled. Several samples of 2 to 24 hours duration were taken over a 24 hour period. Values ranged from 15 ng/m^3 to 25 ng/m^3 at one location and from 3 ng/m^3 to 36 ng/m^3 at a second location. The second location was sampled again with a 6 hour sampling period. No

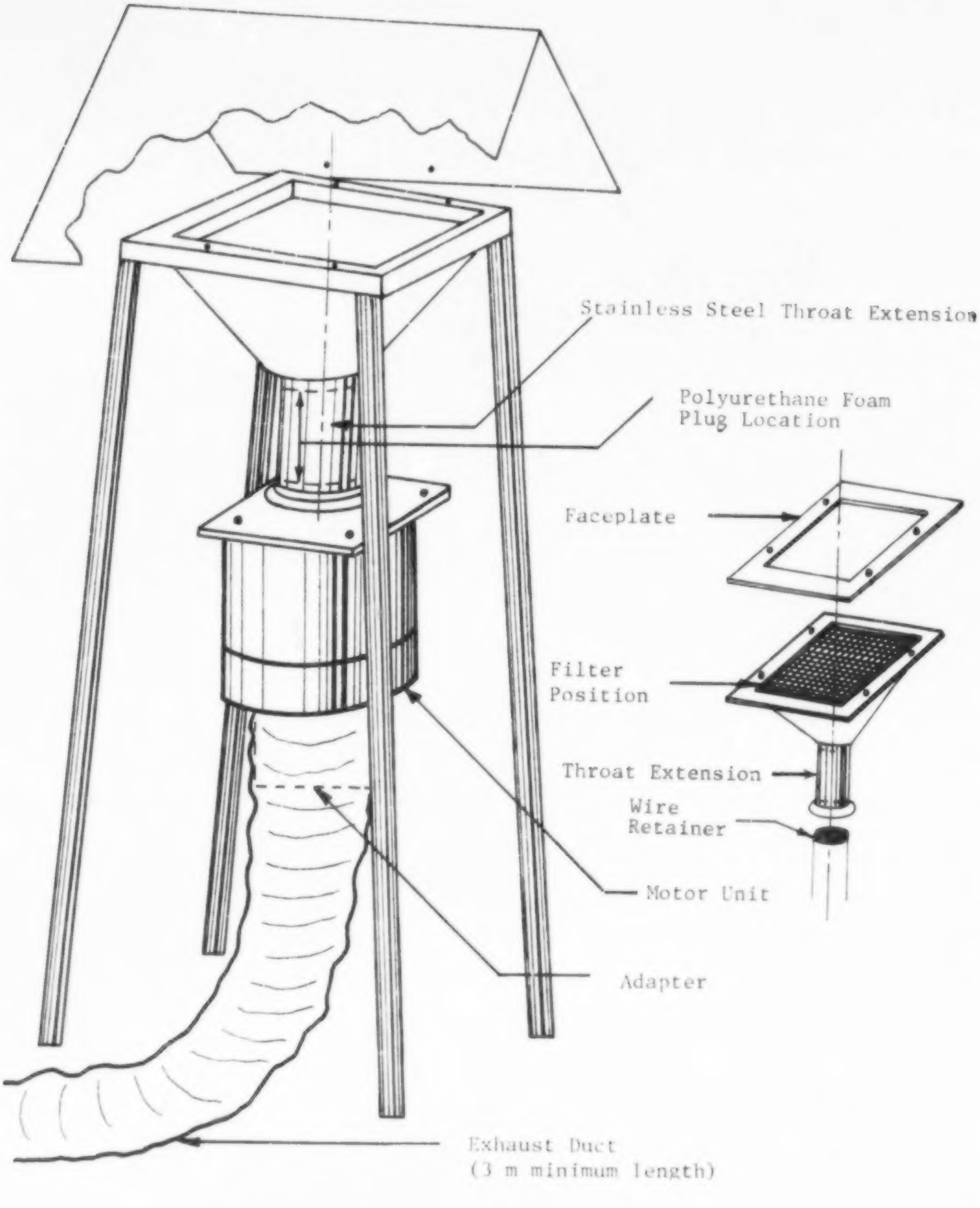

Stainless Steel Throat Extension
Polyurethane Foam Plug Location
Faceplate
Filter Position
Throat Extension
Wire Retainer
Motor Unit
Adapter
Exhaust Duct (3 m minimum length)

Figure 18. Assembled sampler and shelter with exploded view of the filter holder (65).

PCBs were detected. A third test at the second location was performed with 4-hour sampling durations over a 24 hour period. PCB concentrations varied from 4 ng/m^3 to 9 ng/m^3. Several other field tests are also described.

MacLeod (90) sampled indoor and ambient air with a high volume sampler modified to use polyurethane foam as a collection medium for PCBs.

2.3.1.2.4 Recommended method--If ambient air monitoring for PCBs is to be performed during a PCB Trial Burn, it is recommended that a high volume sampler incorporating polyuretahne foam as described by Stratton, et al. (65) be used. This is an adequately tested methodology and offers the substantial advantage of sampling much larger volumes of air than any other method.

2.3.1.3 Liquid Sampling--

Liquids are typically taken by what is termed grab sampling. A contained liquid is generally taken by tap sampling. A tap, either existing or installed in a line or container, is opened, and the sample is conducted into an appropriate container. (Samples for organic analyses are best taken in amber glass bottles with non-adhesive Teflon lid liners.) If the liquid is at elevated temperature, it is passed through a cooling coil before entering the sample container. Dipper sampling is appropriate to sampling sluices, ponds, open discharge streams, and rivers.

A grab sample is representative of the liquid stream only at the time of acquisition. Consequently, samples need to be taken repeatedly throughout the duration of a test in order that process variations that give rise to composition changes in the stream are adequately tested. If numerous samples are necessary, an automatic composite sampler, such as that described by Grant (50), can be used.

Additional methods of sampling liquids are provided in a recent EPA manual (53) published in support of physical/chemical testing required by RCRA.

2.3.1.4 Solid Sampling--

Samples of non-biological samples (e.g., solid waste feeds, fly ash, ash) are generally acquired by grab sampling. Soils and sediments are generally sampled by trenching or core boring. Several samples of a particular solid stream should be taken over the duration of the test. The American Society for Testing Materials (52) has published a procedure for preparing composite samples. Other methods are described in Reference 53.

2.3.1.5 Personnel Monitoring--

MacLeod (90) reported on monitoring personnel exposed to PCBs during cleanup operations along PCB-contaminated roadsides in North Carolina. Exposed workers carried Mine Safety Appliances (MSA) Model S samplers. The samplers had polyvinylchloride filters to trap particulates and polyurethane foam plugs to trap vapor phase PCBs. The foam plugs were inserted into glass tubes, 2 cm diameter and 7.5 cm long. Pumps were operated at 2.5 lpm.

A similar method was used by the U.S. Air Force to measure worker exposure to Herbicide Orange vapors (n-butyl esters of 2,4-D and 2,4,5-T) during the disposal of Herbicide Orange vapors. Chromosorb 102 was used instead of polyurethane foam, and filters were not used. MSA Model G pumps pulled sample air through the tubes at 0.5 lpm (91).

2.3.2 Analytical Methodologies

PCBs have been detected by numerous researchers in all environmental media. Indeed, these compounds are considered to be ubiquitous. Significant levels of contamination have been detected in waters, aquatic sediments, soils, and various biota. Data are limited, however, for assessing airborne PCB levels. Further, there are only limited data on PCB emissions from combustion sources and incinerators.

There are several factors which complicate the assessment and interpretation of PCB emissions. First, the term PCB applies not to a single chemical species but to a class of compounds, related by chemical structure and degree of chlorine substitution on the parent molecule, biphenyl. There are 209 possible isomers, ranging from 3 monochloro isomers to 1 decachlorobiphenyl isomer. PCBs are seldom manufactured or used as pure isomers. In industrial applications, PCBs are made and marketed as mixtures, and each of these mixtures contains significant fractions of many of the possible isomers. For example, Aroclor 1242, a commercial PCB product, is comprised of 54 identified isomers (92). Sissons and Welti (1) identified 69 isomers in Aroclor 1254. Such mixtures have been detected in numerous environmental media. The fact that a class of compounds and not a single identifiable chemical species is to be detected and measured greatly increases the complexity of a chemical analysis.

The second complicating factor is that combustion processes change the relative amounts of isomers in the mixture(s) being burned or incinerated. Also, ambient air samples tend to be enriched in the higher volatility, lower molecular weight PCBs and deficient in the lower volatility, higher molecular weight PCBs. Thus, interpretation of analytical results can be difficult.

A third complicating factor is interferences. Combustion sources emit a substantial number of compounds, many of which exhibit extraction and analytical behavior similar to PCBs. Environmental samples frequently contain a variety of pesticides which also exhibit analytical behavior similar to that of PCBs.

2.3.2.1 General Analytical Methodologies--

Gas chromatography (GC) is by far the most widely used analytical method of separating compounds in the vapor phase, and thus GC provides qualitative information about a sample.

Various detectors are employed in GC analysis to measure compounds after separation. The most widely used detector is the electron capture detector (ECD). The ECD responds, in principle, to electronegative atoms, such as halogens. The ECD is enormously sensitive and is capable of detecting picogram quantities of halogenated compounds such as PCBs. The ECD has a limited dynamic range, and its response is linear over only several orders of magnitude. A major complication in the use of the ECD is that response factors to various compounds vary over several orders of magnitude, depend strongly on the degree of halogenation, and depend to a lesser extent on halogen substitution pattern in isomers with the same degree of halogenation. Thus, the analyst's experience and proper preparation of analytical standards are very important in the analysis of PCBs using the electron capture detector.

A less sensitive, and thus less widely used, detector is the flame ionization detector (FID). The FID responds, in principle to carbon-hydrogen bonds. In fully halogenated compounds, there are no carbon-hydrogen bonds; and the FID has negligible response. The FID is capable of detecting nanogram and sub-nanogram quantities of partially halogenated compounds, such as PCBs.

The most powerful current technique for organic compound analysis is gas chromatography followed by mass spectrometry (GC/MS). In theory, every compound will produce a unique mass spectrum. Thus, compounds are separated in the GC, and they are identified and quantified by the mass spectrometer. In practice, it is difficult or impossible to distinguish the mass spectra of similar positional isomers. In general, however, GC/MS provides sufficient identification power for PCB analysis. GC/MS analysis is generally much less sensitive and considerably more expensive than GC/ECD analysis although there are techniques for enhancing the sensitivity of GC/MS. Thus, GC/MS is frequently used to confirm the presence of PCBs in a sample after GC/ECD analysis.

2.3.2.2 Quantitation--

Three general methods of quantifying PCBs have been used either individually or in combination (16). These methods are described below.

2.3.2.2.1 Pattern recognition--The most common method of quantifying PCBs in environmental samples involves comparing the multipeak gas chromatographic elution pattern generated by the sample (after cleanup procedures to remove pesticides and other potentially interfering compounds) with the elution patterns of commercial PCB mixtures. (Because one company was the principal manufacturer of commercial PCBs, each mixture is quite reproducible with respect to isomeric composition and concentration.) This comparison is relatively subjective. The decision is then made as to what commercial product most closely matches the sample pattern. The quantity of PCB present in the sample is calculated by comparing areas of one or more major peaks in the sample with matching peaks in the commercial mixture of known concentration. It is assumed explicitly that all PCB isomers are present in the sample in the same proportion as in the commercial mixture chosen for quantitation. This assumption is generally incorrect. Quantitation by pattern recognition was described in detail by Hutzinger, et al. (92).

Pattern recognition has the following advantages:

- It is well suited to gas chromatographic analysis, which is simpler and less expensive than GC/MS analysis.
- It identifies a commercial mixture which can aid in identifying the source of the contamination.
- It is more sensitive than some GC/MS methods and allows for more accurate quantitation if samples are not complex or altered by combustion, weathering, or biological processes.

Pattern recognition has the following disadvantages:

- Combustion source and environmental samples will have altered patterns because of depletion of some isomers. Thus, recognition of a pattern may not be possible. Even if a pattern is recognizable, quantitation of a PCB mixture with an altered isomeric or concentration composition would be inaccurate and potentially misleading.
- Many environmental samples also contain various pesticides, some of which have extraction and chromatographic behavior similar to PCBs. Thus, pattern recognition may not be possible, and quantitation may be inaccurate.

2.3.2.2.2 Derivatization--Derivatization involves converting all PCB isomers in a sample to decachlorobiphenyl (DCB) by reaction with antimony pentachloride. DCB is fully chlorine substituted, so that there is only a single isomer.

Derivatization has the following advantages:

- It considerably simplifies the analysis by converting all PCB isomers to a single isomer.
- It considerably reduces the detection limit when an electron capture detector is used because ECD sensitivity increases with increasing halogen substitution (although not linearly).
- It enables the analyst unequivocally to quantitate DCB.
- It minimizes the necessary analytical judgements involved in the physical measurement of the chromatogram of a multicomponent mixture.

Derivatization has several disadvantages:

- As Armour (93) stated, derivatization to DCB should only be used as a confirmatory technique because of the possible presence of interfering compounds. Biphenyl is frequently found in samples from combustion sources and is converted to DCB.

- The result of the conversion to and quantification of DCB is generally reconverted to an amount of the Aroclor mixture in the original sample. Correction factors range from 0.38 for Aroclor 1221 to 0.79 for Aroclor 1262 (93). The actual factor cannot be known without accurate knowledge of the Aroclor originally present. Because of changes in isomer distribution and concentration in a sample from a combustion source, considerable error can be induced in conversion of a DCB value to the original Aroclor mixture.

- The method is subject to false positives. Haile (94) found several extracts of samples taken at a coal-fired utility plant that produced DCB upon perchlorination in which PCBs could not be confirmed by GC/MS analysis of unperchlorinated portions of the sample. Haile concluded that the extracts contained biphenyl and/or related aromatic compounds that could be converted to DCB and that GC/MS was necessary for verification of PCBs. EPRI (16) noted false positives in the Trial Burn of ENSCO.

2.3.2.2.3 Measurement of individual components--Because of the disadvantages of pattern matching and derivatization, Webb and McCall (95) proposed analysis by GC using ECD detection using Aroclor standards in which the quantitative composition of each peak is known. Using GC/MS and GC with an electrolytic conductivity detector, Webb and McCall determined the empirical formula and the amount of chlorine represented by each peak in a series of Aroclor standards.

Eichelberger, et al. (96) proposed a GC/MS method in which selected ions were monitored. Their study indicated that single ions characteristic of mono- through hexachlorobiphenyl could be monitored and thus provide enhanced sensitivity over the usual method of scanning a large mass range (e.g., 50-500 amu) repetitively during the chromatogram. During the usual mode, the MS spends only a very small fraction of the total scan time focusing ions of each m/e ratio. Thus, most of the information provided by the MS (as much as 95-99%) is not relevant. When the MS is made to focus repetitively on a limited number of ions of known significance, the amount of time spent counting each of the limited number of ions is greater than when all ions are scanned. Sensitivity is thus enhanced. In a library search of mass spectra, Eichelberger, et al. found very few and only minimally interfering compounds.

Levins, et al. (97) examined methods used for PCB analysis, recommended a procedure, and performed verification testing. Their work was performed because conventional PCB analytical methods are frequently difficult to apply to samples derived from combustion sources or ambient air. Their approach is fully described in Reference 97. It is a GC/MS technique involving the following steps:

- Acquire GC/MS data in PCB subset mass windows large enough to encompass all isotope clusters.
- Examine selected mass spectra to verify the presence of PCBS by their chlorine isotope abundance patterns.
- Generate mass chromatograms from a single mass chosen to represent each chlorobiphenyl isomer (e.g., mono-, di-, tri-, etc., chlorobiphenyl).
- Integrate areas in each mass chromatogram only in the retention time region corresponding to each chlorobiphenyl isomer.
- Quantitate from selected peaks in Aroclor reference standards or with pure isomers.

Advantages of the techniques for measuring individual isomers are:

- Accuracy is not dependent on correct identification of an Aroclor mixture. Thus, samples altered by a combustion source, weathering, or metabolism can be quantitated as accurately as pure standards.
- They eliminate the additional analytical step of perchlorination and the problem of false positives.

Disadvantages of the technique for measuring individual isomers are:

- There is a reduction in sensitivity relative to GC-ECD. Repetitive scanning GC/MS can involve a sensitivity loss of 10^3-10^5 (96). Selective ion monitoring (96,97) results in an increase in sensitivity, but GC/ECD is still more sensitive.
- GC/MS analyses are considerably more expensive than GC/ECD analyses.

2.3.2.3 Methods Used in Past PCB Destruction Tests--

Samples taken at the PCB incineration tests conducted by Ackerman, et al. (11,12) were treated as follows: 1) probes were rinsed with acetone; 2) filters were desiccated to constant weight; 3) probe rinses were filtered and the solids added to the filter catches; 4) filters were extracted in Soxhlets with pentane to which the filtered probe rinse had been added;

5) the XAD-2 resin samples were extracted in Soxhlets with pentane and then methanol; 6) scrubber water samples were liquid-liquid extracted with pentane; and 7) solid ash residues were extracted in Soxhlets with pentane. Extracts were dried with anhydrous Na_2SO_4 and concentrated to 10 ml in Kuderna-Danish concentrators.

GC/MS in the selected ion monitoring mode was used to analyze the sample extracts (samples, blanks, controls, standards) for PCBs. Seven sets of molecular ions were scanned to determine mono- through octachlorobiphenyl. Total ion current measurements on standards and controls were used for quantitation. Detection limits were 3-5 ng per 5 μl injection or about 5 $\mu g/m^3$ in the combustion zone gas, 7 μg/l in scrubber water, and 0.1 mg/kg in ash samples.

Haile and Baladi studied (17) PCB analytical methodology as part of their method development work. Florisil and water samples were spiked with various Aroclors. Soxhlet and triple liquid-liquid extractions were used to recover spiked Aroclors. Extracts were concentrated to 10 ml and analyzed by GC-ECD. Recoveries were good, but it was noted that the concentration step may lose varying amounts of the more volatile PCBs. (Evaporating PCB-containing extracts to dryness will certainly cause substantial loss of the more volatile PCBs.)

Sample cleanup techniques were also studied (17). Equilibration of hexane extracts with concentrated sulfuric acid destroys many potentially interfering compounds, particularly aromatics. Adsorption column chromatography on Florisil is widely used (38) for separating PCBs from potentially interfering compounds. Haile and Baladi (17) recommended routine sulfuric acid treatment followed by column chromatography, if necessary.

Standard perchlorination methods (93,98) were tested and modified to increase conversion yields of lower PCBs (17). Satis factory yields were obtained by the modified procedure. Conversion of PCBs to decachlorobiphenyl by treatment with $SbCl_5$ also converts biphenyl to DCB, thereby causing an over estimate of total PCBs. Several methods for removing biphenyl were tried (17) but caused substantial losses of lower molecular weight PCBs.

Samples from the field verification tests of Haile and Baladi (17) were recovered and analyzed as described below. Florisil samples containing sorbed PCBs were placed in Soxhlets and extracted with hexane. The empty trap was rinsed with acetone and hexane; these rinsings were placed in the Soxhlet extractor. The extracts were cooled, transferred to Kuderna-Danish evaporators, concentrated to about 10 ml, and placed in separatory funnels. Contents of the first three impingers were combined into one container. In the laboratory, this sample was extracted three times with hexane. The extract was added to a Kuderna-Danish concentrator, concentrated to about 5 ml, and dried with anhydrous Na_2SO_4. This extract was added to the Florisil extract. The impingers were washed with water, extracted with hexane, concentrated and dried as above, and added to the Florisil extracts. The combined extracts were shaken with concentrated H_2SO_4 and then concentrated to about 5 ml. (This extract could be processed through a second cleanup step, column chromatography on Florisil, if necessary.) The concentrated extract was made to 25 ml, and 5 ml aliquots were taken for perchlorination. The perchlorinated extracts were analyzed by GC-ECD for decachlorobiphenyl. Quantitation was effected by comparison with standard PCB solutions.

Samples taken during PCB destruction tests at a cement kiln (20,21) were extracted with pentane or hexane. Samples on the sorbent traps were recovered by thermal desorption. Analyses were performed by GC-ECD with confirmation by GC/MS. Quantitation was by pattern matching and peak area comparisons.

EPA (22) used GC-ECD for determination of PCBs in samples taken during tests at a pulp and paper mill burning PCB-contaminated waste oil. Xylene from the impingers and xylene rinses of the probe and connecting glassware were combined, concentrated to 3-4 ml, and brought to 10 ml with hexane. Column chromatography on alumina was used to separate PCBs in the sample from potentially interfering substances. The fraction containing PCBs was concentrated to 10 ml, and aliquots were analyzed by GC-ECD. Peak patterns in the samples were matched with those of standards to determine which Aroclors were present. One or more peaks in a characteristic pattern were usded for quantitation by comparing peak heights or areas.

The glass fiber filters were torn into small peices and stirred with hexane. The mixture was filtered, the hexane concentrated to 10 ml, and the concentrate analyzed as above for PCBs.

Stratton, et al. (65) described analytical methodology for PCBs. Exposed polyurethane plugs were extracted in Soxhlets for 3 hours with Nanograde hexane. Filters were extracted in the same way. All plugs can be extracted separately and then combined; or the filter and plugs can be extracted and analyzed separately. Extracts were concentrated with Kuderna-Danish and micro-Snyder apparatus. Evaporation to dryness must be avoided to prevent loss of high volatility, low molecular weight PCBs (e.g., monochlorobiphenyl).

Liquid column chromatography on silicic acid was employed to remove chlorinated pesticides and other potentially interfering compounds. A sulfuric acid cleanup was tested but was found not to be generally necessary.

Analyses were by GC-ECD. Confirmation was effected by chromatography on a second column of quite different polarity. GC/MS was also used for confirmation of PCBs. The primary column, OV-17/QF-1, was a standard pesticide column and is quite polar. The secondary column was non-polar. Gas chromatographic retention times are characteristic; however, numerous compounds may have the same retention time. Chromatographing a sample on two columns of different polarity and comparing the chromatograms with those of standards run on the same columns can be used for relatively unambiguous qualitative identification.

Stratton, et al. (65) point out that in ambient air sampling low molecular weight, high volatility PCB isomers are likely to be enriched relative to higher molecular weight, lower volatility isomers. Thus, the chromatogram of an ambient air sample is not likely to match that of a standard Aroclor. Consequently, quantitation by pattern matching and using peak area ratios can lead to results with significant error. They consider the most logical approach to quantitating PCBs in ambient air samples is perchlorination to and measurement of decachlorobiphenyl. This technique was suggested by Armour (93) and Veith (98) and modified by Haile and Baladi (17). They modified Armour's method to improve the extent of perchlorination of mono- and di-chlorobiphenyl species and to reduce evaporative losses. They also attempted to find a means of removing biphenyl, which is also perchlorinated, but were unsuccessful (as were Haile and Baladi (17)). To determine and correct for biphenyl, Stratton, et al. (65) used GC with flame ionization detection.

Samples taken at the recent Rollins Environmental Services, Inc., PCB Trial Burns were analyzed by a contractor (14) according to the methodology in EPA's interim manual (60). After extraction and concentration, samples were analyzed by GC-ECD. Confirmation of PCBs was performed by GC/MS.

Samples taken by Tennessee Eastman Company (48) in their PCB incineration tests were analyzed as follows. Impinger contents were extracted three times with hexane; the extracts were combined. The impingers were rinsed with acetone, which was added to hexane rinses of the probe and connecting glassware. Florisil samples were Soxhlet extracted with hexane, and the extracts were combined with the train rinses and impinger water extracts. Combined extracts were concentrated to 1 ml. Part of this concentrate was spiked with an internal standard. Complex samples were cleaned up by liquid chromatography on Florisil although this cleanup was not satisfactory for some samples. Analyses were performed by GC/MS. Quantitation was performed by the method proposed by Levins, et al. (97).

The analysis methodology used for samples taken at the ENSCO Trial Burn (15,16) were essentially those of Beard and Shaum (60). Florisil and XAD-2 tubes were extracted with hexane and then combined with hexane extracts of the impinger contents and probe rinse. The combined extract was concentrated to 40 ml: a 35-ml portion for PCB analysis and a 5-ml portion for RCl analysis. The 35 ml portion was concentrated to 5 ml: 3 ml for perchlorination and 2 ml for confirmatory analysis, if necessary. Solid and liquid samples were treated similarly. Analysis of the perchlorinated fractions was by GC/ECD. When decachlorobiphenyl was found, unperchlorinated fractions were analyzed by GC/FID for biphenyl and GC/MS for confirmation of PCBs.

The analysis methodology used for the samples acquired during the Trial Burn performed at General Motors Corporation's plant in Bay City, Michigan was that given in EPA's interim manual (60). Impinger water samples were extracted with hexane, and acetone and hexane rinses of the impingers combined with the extract. This sample was concentrated to ca. 5 ml, dried by passage through anhydrous Na_2SO_4 and then combined with a hexane extract of the Florisil samples. The combined extracts were concentrated and then cleaned up by partitioning with concentrated H_2SO_4 and then methanolic KOH. Analyses were effected by GC-ECD and pattern matching, GC/MS and pure isomeric standards, and perchlorination to decachlorobiphenyl.

In their study of pilot scale PCB waste destruction, Guilford and Brandon (57) used gas chromatography with election capture (GC-ECD) detection to measure the PCB content of the combustion zone gases. Quantitation was performed by: 1) matching peak patterns in the samples with those of standard Aroclor; 2) determining which Aroclor had been initially present; and 3) comparing peak areas. Before use in the impingers, the ethylene glycol was pre-extracted four times with hexane (4:1 glycol to hexane ratio). Samples were extracted with hexane prior to analysis.

Analytical methodology employed by Komaniya, et al. (59) in their laboratory scale study of PCB incineration involved combining the water- and hexane-filled impinger contents in a flask containing acetone, rinsing the impingers and associated lines with hexane, washing the total volume with 1 M NaOH, and concentrating to one-tenth the original volume. Wastewater from the scrubber was repeatedly extracted with hexane, which was then concentrated to about 3 ml. Samples were analyzed by gas chromatography with electron caputre detection. Quantitation was effected by peak pattern matching with authentic PCB mixtures. Destruction efficiencies were greater than 99.99999%.

Guilford and Rosenblatt (58) employed gas chromatography with electron capture and flame ionization detection to measure PCBs in samples taken from their PCB incineration tests. Gas chromatography-mass spectrometry (GC/MS) was used for confirmation. Hexane was used as the extractant for filter, impinger, scrubber water, and sludge samples. Extracts were cleaned to remove potentially interfering compounds by column chromatography on Florisil. Extracts were concentrated to dryness, made to 5 ml with hexane, and refrigerated until analysis. Quantitation of the GC-ECD chromatograms was effected by matching peak patterns in the samples with those of Aroclor mixtures and then comparing the sum of major peak areas in sample and standard chromatograms. The presence of PCBs in the samples was confirmed by GC/MS.

Exposed polyurethane plugs taken by MacLeod (90) were extracted with hexane. The extracts were concentrated to ca. 1 ml and cleaned up by liquid chromatography on alumina. When necessary, further cleanup by liquid chromatography on silica gel was performed to remove pesticides. Analyses were performed by GC-ECD. Pattern matching was used, and the largest peak in the sample chromatograms was compared with the corresponding peak in standard Aroclor solutions.

Burg, et al. (99) extracted filters and Tenax GC cartridges with 80:1 benzene/isooctane in Soxhlet apparatus. Extracts were concentrated to dryness (Rotovap and purified air), taken up in 1 ml of hexane, and cleaned up by liquid chromatography on Florisil. Electron capture GC was employed for analysis; quantitation was performed by pattern matching with standard Aroclor mixtures and comparing peak areas.

2.3.2.4 Recommended Analytical Methodology--

It is recommended that the methodology specified in EPA's interim guide (60) be employed for analyses of samples taken during PCB Trial Burns. The Florisil trap (sample or blank) trap is extracted with hexane in a soxhlet, cooled, and then concentrated to about 5 ml. Contents of the first two (water filled) impingers are extracted with hexane, dried by passing through columns filled with anhydrous Na_2SO_4, and added to the Florisil extract. The probe and impingers are rinsed with acetone then hexane. The rinses are dried with anhydrous Na_2SO_4 and added to the combined extracts. The combined extracts are then cleaned by extracting with concentrated H_2SO_4 (if the cleaned extract is still colored, liquid chromatography on Florisil can be used). The extract is then made to 25 ml volume and split into four portions: three 5-ml volumes for perchlorination and one 10-ml aliquot for confirmation studies by GC/MS. After perchlorination, the solution is extracted four times with hexane and made to 5 ml. Analysis for decachlorobiphenyl is performed by GC-ECD. Chromatographic parameters are:

- Chromatograph - Any suitable instrument.
- Detector - Electron capture, ^{3}H or ^{63}Ni.
- Column - 1.8 m x 2 mm ID, 3% OV-210 on Supelcoport, 100/120 mesh.
- Temperatures - Column 280°C, others not specified.
- Carrier gas - Not specified (N_2 or H_2), 30 ml/min.
- Detection limit - Not specified, but standards of 25 to 50 pg/μl are suggested. The overall detection limit is specified as 10 ng DCB in a 5 ml perchlorination aliquot. This indicates a minimum detection limit of 2 pg/μl injected.

Results are reported in terms of ng DCB per cubic meter of combustion effluent sampled. GC/MS is used to verify the presence of PCBs by pattern matching with Aroclor mixtures. The precision of the DCB analysis is stated to be 10-15%, and recovery of PCBs through the entire sampling and analysis procedure is stated to be 85-95% (60).

It must be repeated that the perchlorination procedure is subject to false positives. Therefore, the importance of adequate test strategy and procedural (sampling and analysis) and reagent blanks cannot be overstated.

2.4 STACK MONITORING INSTRUMENTATION

As used in the PCB Regulations, the word "monitor" is interchangeable with "sample". The latter implies a grab technique or collection of a quantity of material for a specified time period for subsequent analysis. Monitoring, on the other hand, implies continuous measurement of a value (or concentration) for an indefinite period. The stack gases which must be monitored, according to the above definitions, are O_2 and CO. CO_2 and NO_x may be determined periodically. Since the equipment used for CO analysis is also applicable to CO_2, it may be more suitable to monitor CO_2 than to collect a separate sample for analysis. The following two sections describe the types of equipment for determining O_2, CO, CO_2 and NO_x commonly available and used for stack gas monitoring. A partial list is presented in Table 7.

2.4.1 Oxygen Monitors

Commercial monitors are available which function well in the range of oxygen concentration expected from combustion of PCBs. These instruments operate on either of two principles of oxygen detection. One type of

TABLE 7. CO, CO_2, O_2 MONITORING INSTRUMENTATION

Parameter	Manufacturer	Model	Range	Accuracy	Principle
O_2	Joy	44106	0 - 5% 0 - 25%	± 2% FS	Electrochemical
	Teledyne Analytical	311	0 - 10%	± 2% FS	Electrochemical
	Taylor/Sybron	OA-269	Variable	± 0.5% FS	Paramagnetic
	MSA	803	0 - .1% 0 - 21%	± 0.05% O_2	Electrochemical
	Beckman	F2 & G3	0 - 1% 0 - 25%	± 1% FS	Paramagnetic
	Hague International	O_xSen	Variable	± 5% FS	Electrochemical
CO	Joy	44105	0 - 500 ppm	± 2%	Electrochemical
	Energetics Science	Series 2000	0 -4000 ppm	± 1% FS	Electrochemical
	Intersoan Corp.	LD14	0-100, 0-500 ppm	± 2% FS	Electrochemical
	MSA Instruments	570	0 - 100 0 - 500	± 0-1% FS	Electrochemical
	Beckman	865	10 - 100 2 - 200	± 2% FS	Infrared
CO/CO_2	CEA Instruments	RI550A	0 - 2% 0 - 100%	± 2% FS	Infrared
	Beckman	864	0 - 4% 0 - 8% 0 - 15%	± 2% FS	Infrared
	Infrared Industries, Inc.	703	0 - 10% 0 - 30%	± 2% FS	Infrared
	Hayes Improved Model, Van, Water and Rogers	32000-000	0 - 20%	0.1%	Selective Absorption
NO/NO_2	Thermal Electron Company Phillips	PW 9762/02			Chemiluminescence

detector is an electrochemical sensor which monitors the electrochemical reduction of oxygen. These monitors are accurate to ± 5% of the actual oxygen content. Oxidizing gases such as chlorine or bromine are harmful to this type of detector, and large amounts of NO, NO_2, H_2S, or SO_2 can introduce errors. Soda lime traps can be installed before this type of monitor to eliminate measurement errors caused by these acidic gases. A second type of oxygen monitor measures the total volumetric magnetic susceptibility of the sample gas. Since oxygen is the only major component in normal stack gases with a significant magnetic susceptibility, the sensor is oxygen-specific. A photodetector is used to measure the degree of displacement of a light beam deflected from the detector by rotation of a mirror suspended in a magnetic field when the magnetic susceptibility of the test gas changes. Response is linear and rapid.

Calibration of oxygen monitors is usually performed by drawing ambient air through the system and setting the readout of the instrument to 20.9% oxygen. In special cases calibration gases may be used, but for normal stack monitoring this is not required. Calibration checks of a continuous oxygen monitor should be made at the start and end of each sampling run when performed in conjunction with stack sampling and at least daily during routine operation. If the baseline is found to drift appreciably during monitoring, the instrument will require more frequent calibration and should be repaired or replaced.

2.4.2 Carbon Monoxide/Carbon Dioxide Monitors

While other methods exist for monitoring CO and CO_2, the most applicable to stack monitors appear to be based on infrared sensors. In these non-dispersive infrared (NDIR) monitors, the absorption of infrared radiation is measured at wavelengths specific to the subject gas. The amount of absorption is proportional to the content of the analyte in the gas stream. Drift is within 2-5% of full scale in a typical eight hour period, and calibration is performed by drawing gas from a cylinder with a known composition of CO and CO_2 that is close to the concentration being measured (e.g., CO and CO_2 values in the range of 10-100 ppm and 10-15%, respectively). Other monitors for CO are based on the catalytic oxidation of the carbon compound on an active surface. These are usually specific for CO, are subject to significant interference from unburned hydrocarbons, and are damaged by the presence of oxidant gases.

Because CO_2 need not be measured continuously (frequency is specified by the Regional Administrator), methods other than NDIR may be used. A popular method is the Orsat-type analyzer, as manufactured by several vendors, which is based on measuring pressure changes as the sample gase passes through a series of selective adsorbents. Orsat analyzers are considerably cheaper than the NDIR instruments.

2.4.3 NO, NO_2 Monitors

Like CO_2, NO_x must be determined at a frequency specified by the Regional Administrator. The reference method is EPA Method 7 which is a colorimetric technique. There are a number of instruments for determining NO_x which are accepted as equivalent. These methods are based on reducing NO_2 to NO, then reacting the total NO with ozone to produce excited state NO_2, and then measuring the chemiluminescence produced as the excited state NO_2 returns to the ground state. Several monitors switch the sample gas automatically into and out of the NO_2-to-NO converter to give almost continuous readings for NO and NO_2.

2.4.4 Use of Monitoring Equipment

Failure of O_2, CO, or CO_2 monitors must result in shut off of PCB flow or if excess O_2 drops below required levels unless a prior-approval contingency plan exists which outlines alternate measures. Consequently, calibration accuracy, precision, and drift measurements are extremely important.

Performance specifications for continuous stack gas monitors are given in Appendix B of 40 CFR 60. Reference 100 is a useful guide to selection and operation of continuous monitors. Reference 101 is a useful guide to the conduct of calibrations. In order that regulatory violations not occur and that the incineration process not be shut down unnecessarily, it is important that calibration testing be performed to assure that instruments meet performance requirements specified in 40 CFR 60, Appendix B.

2.5 COMBUSTION OF PCBs

The purpose of incinerating PCB-containing wastes is to destroy the PCBs so thoroughly that emissions of undestroyed PCBs to the environment (air, water, solids) will be so low that adverse environmental and health impacts will not occur. It is widely understood that the products of combustion of organic matter are CO_2 and H_2O and that HCl is a product when organochlorines are burned. It is, however, not so widely understood that other products are formed during combustion processes. The formation of products of incomplete combustion (PICs) is of low probability, but traces of PICs are always found in combustion effluents because of the large number of molecules undergoing reaction. Thus, if 1000 gallons per hour of octane are being burned, 5×10^{27} molecules per hour of octane are undergoing reaction. If the probability of forming a particular PIC of molecular weight of 100 were 10^{-12} (one per trillion), then about 0.8μg per hour of that PIC would be produced. Lustenhouwer, et al. (102) recently summarized the literature on the formation and emission of a class of PICs, polycyclic organic matter, including PCBs, from combustion sources. A general discussion of combustion processes as they relate to efficient destruction of PCBs and formation of PICs is presented in this section.

2.5.1 Fuel Characteristics

Three fuel parameters are important in influencing formation of polycyclic organic matter (POM) such as PCBs: the carbon-to-hydrogen ratio and molecular structure of the fuel, the chlorine content of the fuel, and the presence of contaminants and precursors in the fuel.

In general, the higher the carbon-to-hydrogen ratio, the greater the probability of forming POM. Carbon-to-hydrogen ratio and molecular structure are often related. For example, aromatic compounds have higher carbon-to-hydrogen ratios than alkanes. Thus, POM formation is more probable when aromatics are being burned because unsaturated reactants promote additional reactions between hydrocarbon species in a combustion zone and because a ring structure is a more stable building block for forming more complex condensed ring structures. PCBs, of course, are aromatic compounds.

The chlorine content of a fuel is an obviously important parameter that affects formation of chlorinated POM. Thermochemical calculations presented later in Section 2 and in Reference 119 have shown that, in general, the higher the chlorine content of the fuel, the higher the concentrations of chlorinated POM, such as chlorobenzenes, in the combustion product. Chlorobenzenes are known precursors of PCBs, as well as toxic polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) under pyrolytic conditions. Chlorine is present in the fuel whenever PCBs are burned.

2.5.2 Combustion Process Characteristics

Combustion theory is presented in some detail in Section 2.1. The brief discussion below is adapted to combustion of PCBs. Five combustion process parameters have major impacts on the formation of POM: 1) reaction temperature within the combustion and post-combustion zones; 2) residence time of reactants (air and fuel) and products in the high temperature zone; 3) turbulence or mixing efficiency of fuel and air; 4) air/fuel ratio including the effects of operating cycles on combustion air supply; and 5) fuel feed size.

Experimental evidence from laboratory studies indicates that with adequate residence time and efficient mixing between air and fuel, temperatures in the 800-1000°C range will cause extensive to complete destruction of PCBs (103-108). Thermal destruction tests on PCBs cited in Section 2.2 indicate that essentially complete destruction occurs in well designed systems. On the other hand, pyrolytic conditions favor the formation of PCDFs.

The residence time necessary and the reaction temperature that must be sustained for near-complete destruction of PCBs are interrelated. The higher the temperature, the shorter the required residence time. The PCB Regulations call for residence time of at least 2 seconds at 1200 ± 100°C (3% excess oxygen) and at least 1.5 seconds at 1600 ± 100°C (2% excess oxygen) for Annex I incinerators burning liquid PCBs. There is ample evidence that properly designed systems produce adequate residence time for destruction of PCBs.

Duvall and Rubey (103) and Duvall, et al. (104) have conducted sophisticated experiments on thermal decomposition of PCBs and other organochlorine compounds. Their Thermal Destruction Analyses System (TDAS) works as follows: the sample is inserted into the system, gradually vaporized into a flowing carrier gas, and subsequently subjected to a controlled high temperature exposure in quartz tube reactor. Compounds exiting from the high temperature zone are separated and analyzed by an in-line GC/MS.

Table 8 is taken from the work of Duvall, et al. (104) and shows percents of those PCB isomers remaining after 2-second exposure at various temperatures in flowing air. It is seen for these isomers that adequate destruction does not occur even at 2 seconds at 775°C. (Based on the requirement of not more than 1 mg emitted per kg of non-liquid PCBs fed into an Annex I incinerator, the percentage remaining in the stack gas must be not greater than 0.0001%.)

TABLE 8. PERCENT OF PCBs REMAINING AFTER EXPOSURE AT DIFFERENT TEMPERATURES (104)

	Exposure Temperature (°C)*						
Compound	550	650	675	700	725	750	775
Tetrachlorobiphenyl (2,2', 5,5')	100	92	74	57	21	0.14	--
Pentachlorobiphenyl (2,2', 4,5,5')	100	98	80	53	9.3	0.05	0.007
Hexachlorobiphenyl (2,2', 4,4', 5,5')	100	100	73	26	--	--	0.005

* 2-second residence time, flowing air.

Table 9 is taken from the work of Duvall and Rubey (103) and shows percents of biphenyl and three PCB isomers remaining after treatment at 704°C for three residence times in flowing air. It is seen that none of the residence times at 704°C provide adequate destruction.

It is important to note that the TDAS is a pre-mixed system where the fuel (e.g., PCBs) is intimately pre-mixed with the oxidant (i.e., O_2 in air). In such systems, physical processes, such as vaporization and diffusion, do not dominate chemical reaction kinetics as they do in diffusion limited systems, such as real-world incinerators in which fuel and air are not pre-mixed. Thus, laboratory scale thermal destruction research instruments like the TDAS provide "best case" or minimum necessary thermal destruction measurements. Real-world incinerators (and other combustion devices) will require higher temperatures and/or longer residence time than those determined in the TDAS to achieve the same level of completeness of destruction.

TABLE 9. PERCENT PCBs REMAINING AFTER TREATMENT AT 704°C (103)

	Residence Time, Sec *		
Compound	0.27	0.95	3.84
Biphenyl	8.1	0.7	0.07
2,2', 5,5' -	78.5	14.0	2.6
2,2', 4,5,5' -	81.1	18.5	3.4
Decachloro-	84.7	37.3	16.1

* In flowing air.

Data provided by systems such as the TDAS are valuable, for they provide minimum thermal destruction conditions from which incinerator operations can be planned. These data can be obtained more rapidly, less expensively, and in greater amounts than can be obtained from testing incinerators.

The most important reason for incomplete combustion of fuel is lack of turbulence or incomplete mixing of fuel, air, and combustion products. Incomplete combustion of PCB-containing wastes could lead to increased emissions of PCBs as well as PCDFs produced in the process. Previous PCB incineration tests described in Section 2.3 show that well designed systems provide sufficient turbulence that fuel, air, and combustion products are adequately mixed.

Fuel feed size is the fifth important combustion process parameter. In liquid burner systems, the fuel is atomized into the combustion zone. Droplets evaporate at a rate controlled by molecular diffusion. It is the fuel vapor that actually burns, thus the rate of evaporation is the rate controlling step in the combustion process. The smaller and narrower the initial droplet size distribution, the more rapid is the rate of evaporation, which promotes better combustion.

Combustion of solids involves a series of repeated steps (10). First, volatiles near the surface vaporize and burn. The residual solid surface then burns out, exposing fresh, unreacted solid. The process is repeated until the particle is consumed. The larger the particle, the more times the process is repeated, and the longer is the required residence time. An incineration test of whole PCB-containing capacitors showed detectable amounts of PCBs in solid residues, while PCBs were not detected in a test of shredded capacitors incinerated under similar conditions (11,12). In conducting a pilot scale study of PCB incineration, Guilford and Brandon (57) found adequate destruction of liquid PCBs but were unable completely to destroy PCBs in PCB Capacitors.

2.5.3 Formation Mechanisms

This section discusses in a general manner the chemistry of POM relevant to formation and/or survival in combustion sources. Normally, POM is defined as that class of compounds with more than two fused aromatic rings. Thus, naphthalene, consisting of two fused benzene rings, is the simplest form of POM. For the purposes of this document, the definition of POM is expanded to include those compounds with two or more aromatic rings which are not necessarily fused.

Stability is the outstanding characteristic of POM. Compared with non-cyclic organic matter of comparable carbon-to-hydrogen ratios, POM is much less susceptible to thermal degradation and chemical attack. The major consequences of the stability of POM are: 1) the tendency of POM to form during combustion and 2) the persistence of released POM in the environment. PCBs are extremely resistant to chemical and thermal degradation which is why they were produced and used in such large quantities. They are known to be highly persistent in the environment.

It has been shown that there is evidence for emissions of PCBs from combustion sources, and there is considerable evidence for emissions of POM from combustion sources (102). As will be described in subsequent sections, there are plausible mechanisms for formation of PCBs from combustion of such precursor compounds as chlorobenzenes. There are also plausible routes for formation of PCBs from species normally found in combustion zones.

2.5.3.1 Stability of Aromatic Compounds--

The fundamental concept of aromatic chemistry is the theory of resonance bonding which explains the enhanced stability of POM relative to non-aromatic compounds. The simplest aromatic compound is benzene. The benzene molecule is actually a hybrid of the two principal and other resonance structures. Each carbon-carbon bond is of 1-1/2 order, confirmed by the fact that the carbon-carbon bond length of benzene of 1.397 Å is intermediate between the single bond length of 1.544 Å and the double bond length of 1.334 Å (109). Also, the carbon-carbon bond energy of benzene (124 kcal/mole) is intermediate between the single and double bond energies of 80 and 140 kcal/mole, respectively. The extra stability of the benzene molecule relative to the two primary resonance hybrids is termed the resonance energy and is assigned a value of 37 kcal/mole (109). Resonance stabilization results from the availability of additional electrons which strengthen bonds and a molecular structure which permits the extra electrons to move freely which reduces electron-electron repulsion (the delocalization effect). As benzene rings are fused, the extra electrons are shared and delocalized across the system leading to greater stability.

Resonance theory also explains the enhanced stability of halogenated aromatics relative to unhalogenated aromatics. In addition to the two principle resonance hybrids of benzene, the presence of, e.g., a chlorine atom, causes other forms to contribute to resonance stability because of the availability of unshared electron pairs on the chlorine (109). While these structures contribute only about 6 kcal/mole to the resonance energy of chlorobenzene, the result is an increase of about 15% of double bond character to the C-Cl bond. As additional chlorine (or other halogens) are added, resonance energies and C-Cl bond strengths increase up to hexachlorobenzene.

The simplest fused ring POM is naphthalene which has three principal resonance hybrids. Resonance among these structures stabilizes naphthalene relative to benzene: 75 kcal/mole versus 37 kcal/mole (109).

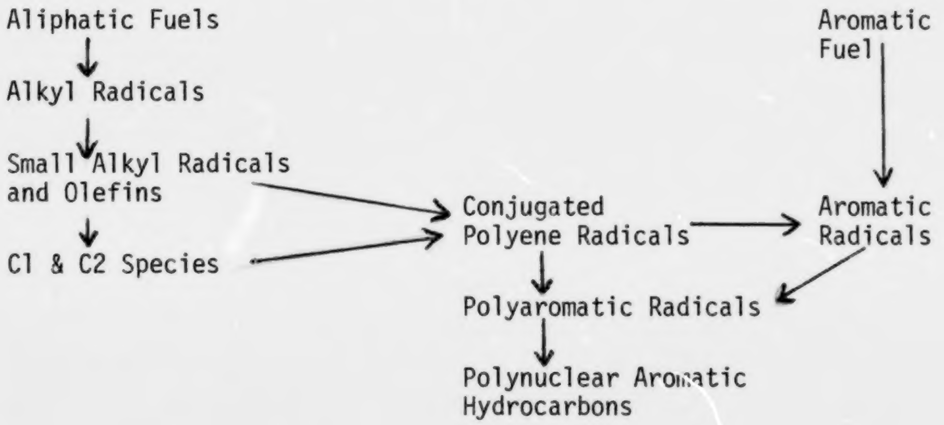
The simplest non-fused ring POM is biphenyl, the parent compound of PCBs. Because the rings are not fused, the extra resonance stability of naphthalene does not occur, and biphenyl is stabilized only an extra 5 kcal/mole relative to benzene. Adding chlorines to biphenyl causes additional resonance hybrids to contribute, as in the case of benzene. Furan is also resonance stabilized, and its resonance stability is ascribed to the participation of one pair of unshared electrons from the oxygen to complete the aromatic sextet. The resonance stabilization energy is 23 kcal/mole (106), less than that of benzene (37 kcal/mole). The presence of benzene rings in dibenzofuran provides additional resonance stability. Similarly, 1-4 dioxin gains additional resonance stabilization from the addition of benzene rings to make dibenzo-p-dioxin. Adding chlorine to furan, dibenzofuran, 1,4-dioxin, or dibenzo-p-dioxin provides greater stability than in the parent compounds for the same reasons described for chlorobenzenes.

2.5.3.2 Reaction Path Analysis--

In practical combustion systems, fuel and air are not pre-mixed on a molecular scale. Rather, practical combustion devices burn fuel in a turbulent diffusion flame, in which the overall reaction rate and completeness of combustion are controlled by physical processes (Section 2.1). Practical devices are thus in contrast to pre-mixed devices in which chemical reaction rates rather than physical processes are the controlling factors.

In turbulent diffusion flame devices, pyrolytic reactions may occur over a wide range of operating conditions and temperatures. In a well designed incinerator, however, the extent of pyrolytic reactions is small, and the probabilities of formation of reduced compounds are very low. However, all real incinerators will produce, trace or ultratrace quantities of reduced compounds. For example, pre-combustion reactions occur before mixing of fuel and air, so that pyrolytic reactions occur on the fuel side of a diffusion flame. Products of these types of reactions include fuel fragments and unsaturated species such as olefins and acetylenes. They do not include oxidizing species such as O and OH. These pyrolytic reactions on the fuel side continue until mixing with air occurs. If final mixing is poor, relatively large quantities of pyrolysis products from precombustion reactions may enter the post-flame region. Another source of pyrolysis products is thermal quenching at furnace walls. Although temperatures in the immediate post-flame region are high enough to effect complete combustion, the stagnant gas layers nearest the furnace walls are not completely mixed with the bulk of hot gases in the post-flame region. The small amount of pyrolysis products produced by thermal quenching can react via polymerization and association to form higher molecular weight species, such as POM, as the combustion gases cool after the post-flame region. It should be emphasized that well designed incinerators produce only trace/ultratrace quantities of pyrolysis products.

Fuels containing large concentrations of olefins or aromatics generally produce effluent gases containing relatively higher amounts of POM, than fuels with low amounts of olefins or aromatics. However, POM has been found in the effluent gases from the combustion of simple fuels like natural gas which indicates the occurrence of pyrosynthesis reactions even in relatively efficient combustion systems. Currently, detailed reaction paths leading to the pyrosynthesis of POM are unknown. A general synthetic mechanism for PAHs has been proposed (10):


Aliphatic Fuels
Alkyl Radicals
Small Alkyl Radicals and Olefins
C1 & C2 Species
Aromatic Fuel
Conjugated Polyene Radicals
Aromatic Radicals
Polyaromatic Radicals
Polynuclear Aromatic Hydrocarbons

This scheme recognizes the enhanced POM-producing characteristics of aromatic fuels, the necessity of free radical chain reactions to produce POM, and the enhanced stability of aromatic systems, particularly conjugated aromatics. The condensation of aromatic and conjugated polyene radicals to form poly-benzenoid radicals can occur by the well-known Diels-Alder condensation reaction.

In the presence of chlorine and oxygen, it is possible that the synthetic scheme proposed for PAH formation can lead to the formation of PCBs, polychlorinated dibenzo-p-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs). In Section 2.5.3.1, it was shown that these three classes of compounds are not as greatly resonance stabilized as conjugated aromatics, hence the probability of their formation is lower.

The probability of formation is enhanced by the presence of chlorine in the fuel. Chlorine atoms bound to aromatic molecules present in the fuel may be retained through the flame zone. Chlorine atoms bound to nonaromatic compounds are likely to be released as chlorine atoms or molecules, or as HCl. Chlorine atoms thus released are reactive and will participate in chain reaction free radical mechanisms until captured by stabilizing compounds (e.g., aromatic molecules) or until the combustion gases are cooled (10).

2.5.3.3 PCB Formation--

PCBs have been found in emissions from combustion sources. Vick, et al. (110) found PCBs in stack emissions and ash in a facility generating electricity from burning a mixture of coal and refuse. Eiceman, et al. (111) found biphenyl, chlorobiphenyl, and a variety of PCDDs, PCDFs, and chlorophenols in fly ash from a municipal incinerator.

Buser (105) found PCBs in the pyrolyzates of tri-, tetra-, and pentachlorophenols. PCDDs, PCDFs, and chloronaphthalenes were also found. No formation mechanisms for PCBs were discussed, but the probability of their formation is low because chlorophenols can condense or dimerize to form three-ring systems (e.g., PCDFs and PCDDs) which are lower in energy than the two-ring PCBs.

2.5.3.4 Formation of Other Compounds from Combustion of PCBs--

In a series of papers, Buser, et al. (107) and Buser and Rappe (108) studied the formation of PCDFs resulting from pyrolysis of PCB mixtures and individual isomers. Complete PCB destruction (107) was noted at 700°C, and no isomerization or dechlorination to lower PCBs was observed. Pyrolysis of Aroclor 1254 yielded mono-through penta-CDFs at levels of 0.1 to 0.9 percent at temperatures in the range of 550-650°C (107). Above 750°C, no PCDFs were found. Buser and Rappe (108) found that the cyclization process which yields PCDFs from PCBs was intramolecular and followed several paths.

Olie, et al. (112) found PCDDs and PCDFs in fly ash and flue gas from some municipal incinerators in the Netherlands. Buser, et al. (113) investigated PCDFs and PCDDs in fly ash and flue gas samples from a municipal incinerator burning mainly household with some industrial wastes and an industrial heating unit burning mainly used industrial oils. They found that the major PCDDs in both fly ash samples were similar and, significantly, were also similar to PCDDs produced by pyrolysis of common commercial chlorophenols.

Rappe and Buser (114) recently summarized research on the formation and degradation of PCDDs and PCDFs by thermal processes. They noted, as has also been discussed in this section, that PCBs can be converted to PCDFs under pyrolytic conditions. They also noted a similarity in PCDF compound patterns formed by pyrolysis of commercial PCB mixtures (e.g., Aroclors) and the PCDF compound patterns found in fly ash samples from municipal incinerators and an industrial heating unit. They conclude that uncontrolled burning of PCBs could be an important source of higher toxic PCDFs and recommend that burning of PCBs be strictly controlled and monitored.

No references to experimental evidence for PCDD formation from PCB burning or pyrolysis have been found, and theoretical considerations indicate that this conversion does not occur.

Carnes, et al. (115) analyzed samples of municipal refuse and solid waste processing streams for PCBs and found them in a number of samples. More importantly, they found PCBs in incinerator residue fines from two units and in fly ash from two units different from the first two.

2.5.4 Thermochemical Equilibrium Analysis

The potential for formation of polychlorinated dibenzofurans (PCDFs) and dibenzo-p-dioxins (PCDDs) during thermal destruction of PCBs can be examined by thermochemical equilibrium calculations. Because accurate thermodynamic data are not available for these compounds, the thermodynamic feasibility of formation of PCDFs and PCDDs was examined indirectly by investigating combustion conditions and waste types that would favor the formation of intermediates, such as chlorobenzenes and chlorophenols.

The first sets of calculations were performed on two hypothetical liquid PCB wastes to examine major combustion product species. Specifications for the program were:

- 250 ppm Aroclor 1254 in kerosene
- 20% Aroclor 1254 in kerosene
- Excess oxygen at 2% and 3%
- Temperatures of 1300, 1400, and 1500°C.

The excess oxygen levels are the minima specified in the PCB Regulations. Results of the calculations are given in Table 10.

It must be emphasized that these are theoretical equilibrium calculations which take no account of kinetics. This is demonstrated by the CO concentrations, which, at temperatures above 1300°C, lead to calculated theoretical combustion efficiencies less than 99.9%. The water-gas shift reaction ($H_2 + CO_2 \rightleftarrows H_2O + CO$) is slow kinetically. Therefore, in the usual combustion source, CO concentrations will not be as high as those predicted by thermochemical equilibrium calcualtions (i.e., values in Table 10), and combustion efficiencies will be higher than calculated from results of these calculations.

A second set of calculations was performed under pyrolytic conditions. The pyrolysis cases assumed the absence or near absence of oxygen and, hence, of oxidizing species. Pyrolytic conditions may be encountered in a real combustion system in several ways:

- Malfunctions or cyclic operation leading to excessively lean air/fuel ratios
- Poor mixing of fuel and air leading to localized oxygen deficient conditions

TABLE 10. THEORETICAL COMBUSTION EFFICIENCIES AND EQUILIBRIUM CONCENTRATIONS OF MAJOR SPECIES FROM COMBUSTION OF TWO PCB WASTES

Composition	Temperature	CE %	CO_2 %	CO ppm	O_2 %	HCl ppm	H_2 ppm	H_2O %
250 ppm PCB, Kerosene	1300	99.99	4.74	11.6	1.98	9	3	12.4
	1500	99.89	4.62	133	1.93	9	37	12.4
	1600	99.70	4.62	365	1.93	9	92	12.3
	1300	99.99	7.54	9	2.99	9	3	11.7
	1500	99.92	7.44	96	2.94	9	26	11.6
	1600	99.76	7.38	281	2.92	9	72	11.6
20% PCB, Kerosene	1300	99.99	4.86	11	1.94	5631	3	10.9
	1500	99.89	4.78	126	1.91	5513	32	10.9
	1600	99.69	4.74	350	1.89	5430	81	10.9
	1300	99.99	7.80	9	2.95	5294	3	10.4
	1500	99.92	7.69	83	2.91	5170	26	10.4
	1600	99.75	7.63	267	2.88	5081	64	10.3

- Thermal quenching of portions of the burning mixture at the walls and carrying of the quenched mixture into the hot post-flame region where pyrolysis can occur
- Pre-combustion reactions on the fuel side of the flame

The thermochemical calculations performed covered the temperature range of 538°C (1000°F) to 1093°C (2000°F) for seven hypothetical wastes of varying carbon, hydrogen, and chlorine content. One case was for a mixture containing 4.2% oxygen, far below stoichiometric requirements. The program used is capable of simultaneously considering a maximum of 200 gaseous species, including alkenes, chlorinated benzenes, and chlorinated phenols (119).

Results of the pyrolytic thermochemical calculations are presented in Table 11. Species with calculated concentrations less than 10^{-6} mole fraction are not listed. Examination of the calculations for the first three cases where the chlorine content is up to 10% leads to the following general observations (119):

- Under pyrolytic conditions, the major equilibrium products are: ethylene, acetylene, methane, benzene, styrene, monochlorobenzene, hydrogen, and hydrogen chloride.
- Concentrations of HCl and monochlorobenzene increase with increasing chlorine content.
- Formation of ethylene, acetylene, and styrene is favored by increasing reaction temperatures.
- Formation of methane and toluene is favored by decreasing temperature.
- In the range studied, temperature appears to have a negligible effect on the formation of benzene, monochlorobenzene, and HCl.

Examination of the calculations for the last four cases, Table 12, for mixtures containing from 50 to 73 percent chlorine leads to the following observations:

- Major equilibrium products from pyrolysis of the highly chlorinated mixtures are: acetylene; benzene; styrene; mono-, di-, tri-, tetra-, penta-, and hexachlorobenzenes; hydrogen chloride in most cases; and CO when small amounts of oxygen are present.

TABLE 11. PYROLYSIS OF CHLORINATED HYDROCARBONS: EQUILIBRIUM PRODUCT DISTRIBUTION AS A FUNCTION OF TEMPERATURE*

Composition of Chlorinated Hydrocarbon	Temperature	Species Concentration, Mole Fraction								
		C_2H_4	C_2H_2	CH_4	C_6H_6	$CH_3C_6H_5$	$CH_2CHC_6H_5$	C_6H_5Cl	H_2	HCl
C, 83.66 wt%	1093°C (2000°F)	1.11E-2	2.10E-2	1.87E-1	2.59E-1	4.69E-3	2.73E-3	5.05E-5	4.88E-1	2.51E-2
H, 13.01 wt%	954°C (1750°F)	7.06E-3	2.86E-3	3.25E-1	2.71E-1	6.89E-3	1.89E-3	3.88E-5	3.57E-1	2.75E-2
Cl, 3.33 wt%	816°C (1500°F)	3.23E-3	2.29E-4	4.81E-1	2.75E-1	9.65E-3	1.13E-3	3.15E-5	1.99E-1	2.99E-2
	677°C (1250°F)	9.59E-4	8.61E-6	6.00E-1	2.75E-1	1.33E-2	5.68E-4	2.72E-5	7.83E-2	3.17E-2
	538°C (1000°F)	1.63E-4	--	6.56E-1	2.70E-1	1.91E-2	2.26E-4	2.42E-5	1.99E-2	3.27E-2
C, 82.89 wt%	1093°C (2000°F)	1.07E-2	2.20E-2	1.68E-1	2.97E-1	5.27E-3	3.28E-3	1.12E-4	4.48E-1	4.45E-2
H, 11.87 wt%	954°C (1750°F)	6.78E-3	3.00E-3	2.91E-1	3.13E-1	7.79E-3	2.29E-3	8.61E-5	3.27E-1	4.84E-2
Cl, 5.24 wt%	816°C (1500°F)	3.10E-3	2.41E-4	4.30E-1	3.19E-1	1.10E-2	1.38E-3	7.00E-5	1.82E-1	5.23E-2
	677°C (1250°F)	9.20E-4	9.07E-6	5.35E-1	3.21E-1	1.52E-2	7.00E-4	6.07E-5	7.13E-2	5.52E-2
	538°C (1000°F)	1.56E-4	--	5.84E-1	3.17E-1	2.19E-2	2.79E-4	5.41E-5	1.81E-2	5.67E-2
C, 81.20 wt%	1093°C (2000°F)	7.26E-3	2.59E-2	8.00E-2	4.82E-1	7.04E-3	6.25E-3	9.21E-4	2.59E-1	1.31E-1
H, 8.79 wt%	954°C (1750°F)	4.64E-3	3.53E-3	1.40E-1	5.07E-1	1.04E-2	4.36E-3	6.83E-4	1.90E-1	1.38E-1
Cl, 10.01 wt%	816°C (1500°F)	2.13E-3	2.83E-4	2.09E-1	5.20E-1	1.48E-2	2.65E-3	5.38E-4	1.06E-1	1.44E-1
	677°C (1250°F)	6.34E-4	1.07E-5	2.60E-1	5.26E-1	2.07E-2	1.35E-3	4.59E-4	4.17E-2	1.49E-1
	538°C (1000°F)	1.08E-4	--	2.83E-1	5.23E-1	3.00E-2	5.43E-3	4.09E-4	1.06E-2	1.52E-1

---

*Minor equilibrium products (mole fraction < 10^{-6}) are not listed.

TABLE 12. PYROLYSIS OF HIGHLY CHLORINATED HYDROCARBONS: EQUILIBRIUM PRODUCT DISTRIBUTION AS A FUNCTION OF TEMPERATURE*

Composition of Chlorinated Hydrocarbon	Temperature	Species Concentration, Mole Fraction											
		C_2H_2	CO	CO_2	C_6H_6	$CH_2CHC_6H_5$	C_6H_5Cl	$C_6H_4Cl_2$	$C_6H_3Cl_3$	$C_6H_2Cl_4$	C_6HCl_5	C_6Cl_6	HCl
C, 47.43 wt%	1093°C (2000°F)	1.21E-2	--	--	4.94E-2	2.99E-4	2.56E-1	2.76E-1	3.14E-1	8.47E-2	7.28E-3	1.28E-5	--
H, 2.56 wt%	954°C (1750°F)	1.60E-3	--	--	4.72E-2	1.83E-4	2.60E-1	2.84E-1	3.20E-1	8.02E-2	6.15E-3	9.37E-6	--
Cl, 50.01 wt%	677°C (1250°F)	4.49E-6	--	--	3.89E-2	4.20E-5	2.58E-1	3.00E-1	3.32E-1	6.79E-2	3.74E-3	3.83E-6	--
C, 29.31 wt%	954°C (1750°F)	2.80E-4	--	--	2.55E-4	1.74E-7	6.41E-3	3.19E-2	1.63E-1	1.87E-1	6.51E-2	4.52E-4	5.45E-1
H, 1.48 wt%	816°C (1500°F)	2.01E-5	--	--	1.85E-4	6.68E-8	5.47E-3	1.04E-2	1.67E-1	1.89E-1	6.21E-2	3.92E-4	5.45E-1
Cl, 69.21 wt%	677°C (1250°F)	6.54E-7	--	--	1.20E-4	1.89E-8	4.39E-3	2.81E-2	1.71E-1	1.92E-1	5.83E-2	3.29E-4	5.54E-1
C, 24.78 wt%	1093°C (2000°F)	3.86E-3	--	--	1.60E-3	3.10E-6	1.83E-2	4.33E-2	1.08E-1	6.43E-2	1.21E-2	4.71E-5	7.48E-1
H, 2.08 wt%	954°C (1750°F)	5.00E-4	--	--	1.45E-3	1.76E-6	1.80E-2	4.42E-2	1.12E-1	6.32E-2	1.09E-2	3.74E-5	7.50E-1
Cl, 73.14 wt%	816°C (1500°F)	3.74E-5	--	--	1.20E-3	8.06E-7	1.68E-2	4.44E-2	1.16E-1	6.23E-2	9.69E-3	2.90E-5	7.50E-1
	677°C (1250°F)	1.30E-6	--	--	9.36E-4	2.91E-7	1.53E-2	4.40E-2	1.21E-1	6.09E-2	8.29E-3	2.10E-5	7.50E-1
C, 37.84 wt%	1093°C (2000°F)	7.35E-3	2.30E-1	2.85E-8	1.11E-2	4.08E-5	7.57E-2	1.07E-1	1.61E-1	5.71E-2	6.46E-3	1.50E-5	3.44E-1
H, 2.12 wt%	954°C (1750°F)	9.67E-4	2.31E-1	9.41E-8	1.05E-2	2.47E-5	7.66E-2	1.11E-1	1.65E-1	5.46E-2	5.53E-3	1.12E-5	3.46E-1
Cl, 55.84 wt%	816°C (1500°F)	7.42E-5	2.31E-1	4.28E-7	9.38E-3	1.25E-5	7.52E-2	1.13E-1	1.69E-1	5.19E-2	4.62E-3	7.91E-6	3.46E-1
O, 4.20 wt%	677°C (1250°F)	2.66E-6	2.31E-1	3.12E-6	8.12E-3	5.19E-6	7.32E-2	1.16E-1	1.74E-1	4.84E-2	3.63E-3	5.05E-6	3.46E-1
	538°C (1000°F)	3.04E-8	2.31E-1	4.66E-5	6.67E-3	1.62E-6	7.05E-2	1.18E-1	1.82E-1	4.34E-2	2.56E-3	2.65E-6	3.46E-1

*Minor equilibrium products (mole fraction < 10^{-6}) are not listed.

- Depending on the ratio of carbon to hydrogen to chlorine, HCl is not necessarily favored by pyrolysis of highly chlorinated mixtures.
- Chlorobenzenes are more favored thermodynamically than chlorinated aliphatic and phenolic compounds.
- The relative equilibrium concentrations of polychlorinated benzenes generally increase with increasing chlorine content of the mixture.
- Reaction temperature in the range examined appears to have a negligible effect on the formation of HCl and chlorobenzenes.
- The presence of small amounts of oxygen does not appear to have a major impact on the equilibrium product distribution except for the formation of CO.

The results of the second set of calculations indicate that, under pyrolytic conditions, formation of chlorobenzenes is thermodynamically feasible. Because chlorobenzenes are known precursors of PCDDs, PCDFs, and PCBs, under pyrolysis conditions these calculations imply that:

- PCDFs and PCDDs may form during the thermal destruction of PCBs carried out under pyrolytic conditions.
- PCDFs and PCDDs may form during the thermal destruction of PCBs carried out under oxidizing conditions in an incinerator if inadequate design and/or operation allow the existence of pyrolytic zones in the system.

2.6 OTHER PERTINENT LITERATURE

Manson and Unger (116) recently reviewed the literature on chemical waste incineration and combustion theory as the basis for predicting destruction efficiencies for hazardous wastes in large commercial incinerators and for scaling such incinerators to larger sizes. They concluded that the state-of-the-art of design theory does not permit a designer to scale up an incinerator with a rigorously predictable destruction efficiency. This inability to predict exactly characteristics of a scaled up process is reflected in Best Engineering Judgement as it relates to the practice of testing processes as they progress from bench to pilot and eventually to commercial scale. The PCB Regulations account for this typical experience by requiring more extensive monitoring of an Annex I incinerator during its first use after a change that is likely to change its emission characteristics (761.40(a)(6)(ii)).

Wilkinson, et al. (117) recently reviewed published and unpublished information on recent and current research and development on pesticide disposal or conversion methods. Incineration was one of the methods studied.

Riley (118) published a study on thermal destruction methods for disposing of organic pesticides. Shih, et al. (119) studied thermal degradation of military standard pesticide formulations on a laboratory scale. Incineration parameters and sampling and analytical methods were discussed.

2.7 SUMMARY

Both theoretical considerations and experiments, at lab scale and commercial scale indicate that essentially complete destruction of PCBs can be effected in Annex I incinerators and high efficiency boilers. On the other hand, both theory and experiment indicate that inadequately designed or improperly operated thermal destruction processes can lead to inadequate destruction efficiency and formation of highly toxic compounds, such as PCDFs and PCDDs. With respect to the formation of PCDFs and PCDDs from the incineration of PCBs, it must again be emphasized that:

- The probability of forming any of these compounds is exceedingly low
- As noted by Dow Chemical Company (19) only the great recent advances in analytical chemistry permits the detection of compounds such as these at ultratrace levels.

In the commercial scale systems described in this chapter, fuel, waste, and air are not pre-mixed. Thus, under the intense temperature conditions at which these systems operate, thermal destruction is controlled by physical processes (heat transfer, vaporization, diffusion) and not by chemical reaction kinetics.

Because physical processes are rate controlling in real world incinerators, it is not possible to take the temperature-residence time values for PCB incineration in Annex I incinerators (2 sec at 1200 ± 100°C or 1.5 sec at 1600 ± 100°C) and extrapolate in a linear fashion to greatly lower temperatures. Chemical reaction rates vary exponentially with temperature. Therefore, reaction rates slow rapidly and non-linearly with decreasing temperature. The physical processes which are rate controlling at high temperatures are less temperature dependent but are strongly dependent on design parameters. Thus, straight line extrapolations will not give meaningful results. Further, data presented in Tables 7 and 8, which were taken in a pre-mixed system where chemical kinetics are rate controlling, show that 2 second exposure at 775°C in air provides an inadequate level of destruction and that exposure at 704°C for 3.84 seconds provides an inadequate level of destruction. It is likely that in a real world incinerator, temperatures of less than 1000°C will not provide the required gas phase destruction efficiency however long the residence time.

Ferguson, et al. (43) constructed a pilot scale experimental incinerator system to study the effect of operational variables on destruction efficiency for several pesticides. They developed a set of primary operating conditions (temperature, residence time, and excess air) which were applicable to the incineration of the organic pesticides they tested and which they believed were applicable to all organic pesticides.

3. ADMINISTRATIVE REQUIREMENTS

The siting and operation of a PCB thermal destruction facility will involve certain legal and institutional policies and procedures which must be considered. This chapter describes the significant Federal regulations and a methodology for obtaining data pertaining to State and local requirements. A general methodology is proposed for public participation and notification.

3.1 FEDERAL RULES AND REGULATIONS

Pertinent Federal rules and regulations must be adhered to, and the appropriate enforcement agency contacted for completed information regarding requirements which may affect the siting and operation of a PCB thermal destruction facility. Table 13 presents an overview of Federal laws and regulations pertaining to PCBs.

The PCB Regulations, 40 CFR 761, implement provisions of TSCA prohibiting the manufacture, processing, distribution in commerce, and use of PCBs. Subpart B sets PCB disposal requirements, and Subpart E includes the following annexes:

Annex I: Specifies operating requirements for high temperature incinerators used for PCB destruction

Annex II: Specifies location, design, and operating requirements for chemical waste landfills used to dispose of PCBs and PCB items

Annex III: Specifies requirements for temporary storage of PCBs and PCB items which have been designated for disposal

Annex IV: Specifies requirements for decontamination of PCB containers

Annex V: Specifies formats for marking PCB items.

Annex VI: Specifies record keeping and monitoring requirements for disposal of PCBs

Regulations pursuant to the Clean Water Act, 40 CFR 129, set toxic pollutant effluent standards for PCBs. No discharge of PCBs is allowed (40 CFR 129.105) from manufacturers of 1) PCBs, 2) electrical capacitors, and 3) electrical transformers. This standard applies to both new and existing sources. While 40 CFR 129.105 includes discharges from incineration areas in manufacturing plants, it does not appear that the standards mandated in 40 CRR 129.105 cover commercial contract incinerator operators because the definition of manufacturers explicitly refer to those who produce PCBs, produce or assemble electrical transformers in which PCBs are part of the dielectric, or produce or assemble electrical transformers in which PCBs are part of the dielectric. Parts 116 and 117 of the Act define discharges under the Act, designate reportable quantities of PCBs spilled into waterways, and designate reporting requirements and fines.

While the PCB Regulations were promulgated under the authority of TSCA, RCRA regulations will have a large impact on PCB disposal. Interim final and final RCRA regulations (40 CFR 264 and 265, 45 FR 33154) state that the PCB Regulations will be incorporated into Phase II RCRA regulations. Parts 264 and 265 establish standards and interim status standards for owners and operators of hazardous waste treatment, storage, and disposal facilities. Pertinent areas covered by parts 264 and 265 standards and interim status standards are: waste analysis, security, inspections, training, preparedness and prevention, contingency plans and emergency procedures, recordkeeping, ground water monitoring, closure, tanks, surface impoundments, incinerators, thermal treatment, and general facility standards.

Under provisions of 29 CFR 1910.1, the OSHA 40-hour week limit for Aroclor 1242 is 1 mg/m^3 and 600 μg/m^3 for Aroclor 1254. In September 1977, NIOSH recommended a time-weighted average for all PCBs of 1.0 μg/m^3. However, the OSHA standard has not yet been changed. This NIOSH value is a recommendation and is not legally binding.

The current time weighted average for PCBs as established by the American Conference of Governmental Industrial Hygienists (ACGIH) is 1 mg/m^3 for Aroclor 1242 and 0.5 mg/m^3 for Aroclor 1254 (120).

Under the Hazardous Materials Transportation Act, regulations in 40 CFR 171-177 cover the transport of hazardous waste materials. The rules place minor recordkeeping requirements on shippers and transporters of

TABLE 13. FEDERAL LAWS/REGULATIONS PERTAINING TO PCBs

Federal Statute	Federal Regulation
Toxic Substances Control Act	EPA, 40 CFR 761, Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions
Clean Water Act	EPA, 40 CFR 129, Toxic Pollutant Effluent Standards
Clean Water Act	EPA, 40 CFR 116, Designation of Hazardous Substances
Resource Conservation & Recovery Act	EPA, 40 CFR 122-124 and 260-265, Hazardous Waste Guidelines and Regulations
Williams-Steiger Occupational Safety & Health Act	OSHA, 29 CFR 1910, OSHA Safety and Health Standards
Hazardous Materials Transportation Act	DOT, CFR 171-177, Transportation of Hazardous Waste Materials

hazardous wastes and prohibit transportation and delivery to improper treatment, storage, or disposal sites.

3.2 STATE AND LOCAL RULES AND REGULATIONS

EPA Regional Offices should be aware of State regulations concerning the siting and operation of PCB thermal destruction facilities. If a Regional Office does not have this information, then the State public health and environmental control agencies should be contacted individually. Also, the States may be able to assist with local agency coordination. At the local level, zoning ordinances must be considered for land use requirements, and various city officials may have a say in the determination of a project as it relates to public safety, health, and welfare.

3.3 SPILL CONTROL AND REPORTING REQUIREMENTS

Prevention of spills of hazardous materials is far superior to cleanup. An established contingency plan is mandatory under the Clean Water Act for safe spill control and prevention. Additionally, RCRA interim status standards for owners/operators of hazardous waste treatment facilities require preparation of a facility contingency plan (45 FR 33224). When the PCB Regulations are incorporated into RCRA, the contingency plan will have to meet RCRA requirements under Section 264.50. A spill coordinator should be assigned for each PCB thermal destruction facility. He should be thoroughly familiar with established safety and reporting procedures. All other personnel likely to be confronted with a PCB spill should also be aware of the proper reporting procedure prior to any actual spill. In addition to the requirements of National and Regional Contingency Plans, any State reporting requirements must also be met. U.S. Coast Guard Regulations require that spills of hazardous substances that may affect water sources should be reported to the National Spill Response Center (400 7th Street, S.W., Washington, D.C., 20590; (202) 426-2675). Appropriate methodology for the control of PCB spills and reporting procedures is addressed in the Manual for the Control of Hazardous Material Spills, EPA-600/2-77-227. EPRI has recently published two documents on utility spill prevention, control, and countermeasure planning for PCBs (121, 122).

3.4 PUBLIC NOTIFICATION AND PARTICIPATION

The PCB Regulations do not explicitly discuss public notification or participation in the approval process. It is not an unreasonable assumption, therefore, that it is the intent of the regulation that PCB thermal destruction facilities should be approved by Regional Administrators on their technical merit alone.

There is ample evidence of local public concern about and opposition to hazardous waste incinerators. Thus, local support for such a facility will be very helpful, if not essential. This section will describe steps that can be taken to enhance public support by providing for an informed public. It will also describe some pitfalls to be avoided.

EPA recently published a proposed policy on public participation in Agency decision-making and rulemaking (45 FR 28911). To ensure effective public participation, EPA defined five basic tasks to be performed. These are described briefly below.

- Identification. Those groups or members of the public who may be interested in or affected by action (i.e., PCB destruction approval) should be identified. The Mayor of the town should be among those identified and notified.
- Outreach. Information about a PCB approval action must be conveyed to the public through mailings, personal communications, public service announcements, media briefings or ads, and other means. The information must include background, timetables, summaries of technical material, and, if possible, a description of social, economic, and environmental consequences.
- Dialogue. The responsible official and interested or affected members of the public must be able to exchange views and explore issues. The dialogue may take several forms: meetings, workshops, hearings, or correspondence. Timely dissemination of information is crucial.
- Assimilation. The results of the "outreach" and "dialogue" tasks must be assimilated into the final decision, and the responsible official must demonstrate that he has understood and considered public concerns.
- Feedback. The responsible official must provide feedback to interested parties concerning the outcome of the public's participation. This feedback must state the action that was taken and indicate the effect that public participation had on the action.

Public concern caused considerable delays in performing a PCB Trial Burn in an industrial boiler at General Motors' Chevrolet plant in Bay City, Michigan. Zelenski and Haupt (46) reported on deficiencies in the public participation process. The major deficiencies were:

- The public was not informed of the proposed permit application in the early planning stages.
- Special interest groups were not informed of the proposal permit application in the early planning stages.
- Plant personnel were not informed in the early planning stages.
- Information needs of the public and special interest groups were not adequately anticipated.
- Information finally supplied was perceived as too technical.
- There was a lack of communication, coordination, and clearly defined responsibilities between participants in the permit approval process.

Zelenski and Haupt (46) made a number of recommendations, several of which are basically the same as will be required by EPA's proposed policy on public participation:

- Identify the concerned public and groups
- Communicate with the concerned public and groups
- Develop a relationship of cooperation with the public and groups
- Determine the level of support and incorporate that in plans for the proposal action.

As noted in Chapter 1, there is a large quantity of PCBs and PCB Items awaiting or that will become subject to disposal, and much of these materials may only be disposed of by incineration in Annex I incinerators or high efficiency boilers. Inadequate public participation in PCB thermal destruction approval processes should not be allowed to compound the PCB disposal problem.

4. EVALUATION OF ANNEX I INCINERATORS

One disposal option for PCBs and PCB Items* is thermal destruction in an approved incinerator. In general, incinerators must meet specific operating requirements set forth in Annex I of the PCB Regulations. An incinerator which meets these requirements or which, based on evidence is capable of operating without presenting unreasonable health or environmental risks from PCBs when one or more of the Section 761.40 requirements is not met, is known as an Annex I incinerator. An incinerator which meets the requirements of Annex I should be approved unless there is some risk of inefficiency noted during the testing and evaluation phase. The waiver section of Annex I (40 CFR 761.40 (d) (5)) provides for approval of units which do not expressly meet all specified operating conditions. These units should not be summarily disregarded as inefficient. The designers or operators may have good evidence, based on calculations, tests, and previous burns with other chlorinated organics, which shows that the unit deserves serious review by EPA.

The process of approving an Annex I incinerator is depicted in Figure 19, which notes appropriate sections of this chapter. The process begins with submission of an Initial Report by the owner or operator of a facility to the EPA Regional Administrator (RA). Following receipt of the Initial Reports, the RA determines whether a PCB Trial Burn is necessary. If a Trial Burn must be held, the owner or operator submits a Trial Burn Plan to the RA for approval. Subsequent to approval of the Trial Burn Plan (with additions and modifications if required), the Trial Burn takes place. Data obtained on incinerator system performance during the Trial Burn are then analyzed. If, based on these data, the RA deems operation of the facility safe, approval is granted.

---

* For the purpose of this discussion, when a term (e.g., PCB Items) is used in the strict sense of its definition in 40 CFR 761.2, it is capitalized.

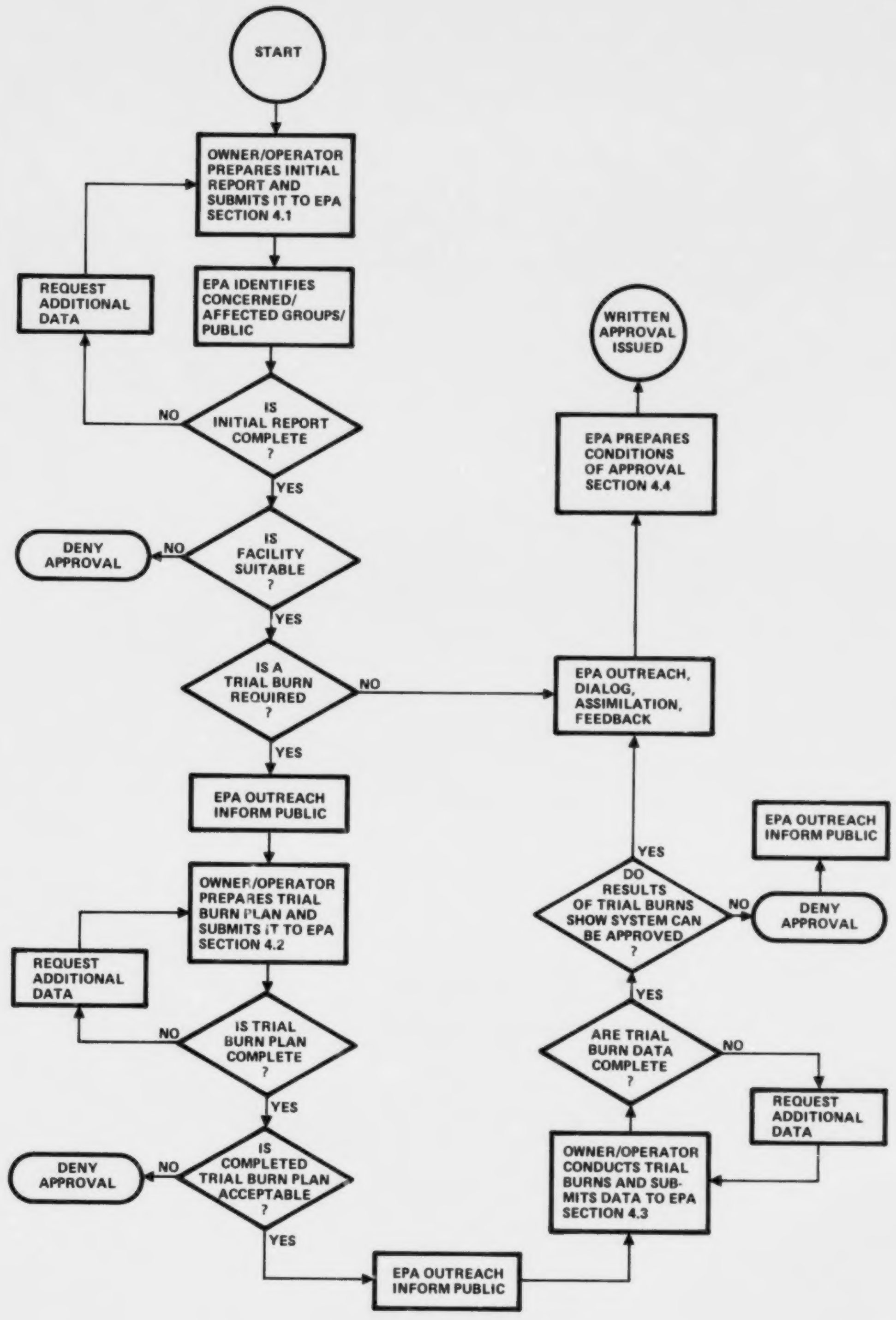

START
OWNER/OPERATOR PREPARES INITIAL REPORT AND SUBMITS IT TO EPA SECTION 4.1
REQUEST ADDITIONAL DATA
EPA IDENTIFIES CONCERNED/ AFFECTED GROUPS/ PUBLIC
IS INITIAL REPORT COMPLETE ?
NO
YES
DENY APPROVAL
NO
IS FACILITY SUITABLE ?
YES
IS A TRIAL BURN REQUIRED ?
NO
YES
EPA OUTREACH INFORM PUBLIC
OWNER/OPERATOR PREPARES TRIAL BURN PLAN AND SUBMITS IT TO EPA SECTION 4.2
REQUEST ADDITIONAL DATA
NO
IS TRIAL BURN PLAN COMPLETE ?
YES
DENY APPROVAL
NO
IS COMPLETED TRIAL BURN PLAN ACCEPTABLE ?
YES
EPA OUTREACH INFORM PUBLIC
OWNER/OPERATOR CONDUCTS TRIAL BURNS AND SUBMITS DATA TO EPA SECTION 4.3
ARE TRIAL BURN DATA COMPLETE ?
NO
REQUEST ADDITIONAL DATA
YES
DO RESULTS OF TRIAL BURNS SHOW SYSTEM CAN BE APPROVED ?
NO
DENY APPROVAL
EPA OUTREACH INFORM PUBLIC
YES
EPA OUTREACH, DIALOG, ASSIMILATION, FEEDBACK
EPA PREPARES CONDITIONS OF APPROVAL SECTION 4.4
WRITTEN APPROVAL ISSUED

Figure 19. Flowchart of Annex I incinerator approval process.

Section 3.4 presented a general discussion of public participation as it relates to the approval process. The approval process flow chart, Figure 19, incorporates steps where public participation is appropriate and, indeed, required by EPA's proposed public participation policy (45 FR 28911). The intent and content of this Chapter is technical. Reference to Section 3.4 should be made for public participation.

This chapter is divided into sections corresponding to the four phases of the approval process. Section 4.1 discusses aspects of facility design and operation and site-specific concerns which must be considered in evaluating the Initial Report. Evaluation of the Trial Burn plan is discussed in Section 4.2, which considers operational data requirements, and monitoring, sampling, and analysis procedures. Section 4.3 discusses evaluation of Trial Burn data. Data reduction and interpretation, as well as means of assessing their completeness and adequacy, are addressed. The technical criteria for incinerator approval and the contents of such an approval are summed up in Section 4.4. Administrative requirements applicable to both Annex I incinerators and high efficiency boilers are discussed in Section 3.

Before getting into the technical heart of this Chapter, it will be useful to examine EPA's strategy in preparing the technical requirements for Annex I incinerators.

A common figure of merit for an incinerator is destruction efficiency:

$$DE = 100 \times \frac{W_{in} - W_{out}}{W_{in}}$$

where DE is destruction efficiency in percent, W_{in} is the mass of waste fed into the incinerator, and W_{out} is the mass of unburned waste exiting from the incinerator. It is important to note that W_{out} is the sum of unburned waste emissions in the three generic effluent streams: stack gas, scrubber effluent, and solid residue.

As noted in the Preamble to the PCB Regulations, Annex I incinerators are capable of achieving 99.9999% destruction efficiency. In establishing technical requirements for Annex I incinerators, EPA had two choices for strategy:

- Mandating a minimum required destruction efficiency, e.g., 99.9999%, or
- Setting limits on unburned PCB emissions

EPA chose the second alternative, setting limits for unburned PCB emissions in each generic process effluent stream. This choice acknowledged several factors:

- Technical limitations of sampling and analysis methodologies
- The relative ease or difficulty in controlling the different effluent streams
- The relative potential environmental impacts of the different effluent streams

Sampling and analysis are both sciences and arts. They are sciences in that there is a large body of validated methodologies for sampling and analysis of organic compounds, including PCBs. They are arts in the sense that effluent streams and samples are all different and that no one technique is optimum for sampling all streams or analyzing all samples. Thus, the strategy of mandating a minimum acceptable destruction efficiency might:

- Give rise to situations where the state-of-the-art sampling and analysis techniques would be inadequate to demonstrate achievement of that destruction efficiency
- Cause unnecessary and increased expense in modifying sampling and analysis methods for particular samples
- Give rise to difficulty in comparing the effectiveness of different incinerators if different sampling and analysis methods were used in testing.

The most voluminous process effluent stream from an incinerator is the stack gas. Scrubbers for control of HCl and particulate emissions are relatively easily implemented control devices. However, control of organic vapor emissions in stack gases is well beyond the state-of-the-art of control technology. EPA set a limit on maximum PCB emissions to the air from the stack gas (1 mg PCBs per kg of PCBs fed) while burning non-liquid PCBs (761.40(b)(1)). No limit was set for stack gas emissions during incineration of liquid PCBs. However, non-liquid PCBs are typically more difficult to incinerate than liquid PCBs, so that there is a higher probability of greater stack gas emissions of PCBs during incineration of non-liquid PCBs. Thus, an Annex I incinerator that can achieve stack gas emissions of PCBs of less than 1 mg per kg fed while burning non-liquid PCBs has a high probability of producing considerably lower PCB emissions while burning liquid PCBs.

In contrast to the stack gas, scrubber effluent is much less voluminous than the stack gas, and because the scrubber is downstream of the combustion chamber(s), scrubber solution comes into contact with only trace or undetectable levels of unburned PCBs. No explicit limit on the PCB content of the scrubber effluent is given in the PCB Regulation. However, it is required (761.40(a)(9)) that the scrubber effluent be monitored and that it comply with applicable effluent or pretreatment standards and any other state and Federal laws and regulations. Thus, other regulatory schemes set limits on PCB emissions in liquid process streams to the environment from Annex I incinerators.

The least voluminous effluent stream from an incinerator is the solid residues. Consequently, this stream is the easiest to handle. In a typical rotary kiln, solids spend in excess of 0.5 hours at temperatures above 900° C, which is sufficiently hot to vaporize and degrade PCB content of the solids to trace or undetectable levels. As noted in Sections 2.1 and 2.5, the degree of comminution of solids fed to the rotary kiln (or other solids combustor) is an important parameter in achieving complete destruction of PCBs. Therefore, no explicit limits or the PCB content of the solid residue stream is given, and there is no reference to any applicable regulatory criteria. However, it is a reasonable inference that the PCB Regulations govern disposal of this type of stream. Thus, if the solid residue from an Annex I incinerator contains less than 50 ppm PCBs, its disposal is not governed by the PCB Regulation. Conversely, if the solid residue contains greater than 50 ppm PCBs, it is subject to the disposal requirements of the PCB Regulations: Annex I incinerator, Annex II chemical waste landfills, or other approved disposal method.

The only disadvantage to EPA's strategy is that the determination of a single figure of merit - destruction efficiency - is not required. This may cause some confusion because of the historical use of destruction efficiency and will make it difficult to compare the performance of different incinerators. Since sampling and analysis of all process streams is required, it is recommended that overall destruction efficiency be calculated from Trial Burn data.

4.1 EVALUATION OF INITIAL REPORT

The PCB Regulations, 40 CFR 761.40(d)(1), specify the information which must be included in an operator's initial report to the RA. This information includes the following:

- The location of the incinerator
- A detailed description of the incinerator including general site plans and design drawings of the incinerator
- Engineering reports or other information on the anticipated performance of the incinerator
- Sampling and monitoring equipment and facilities available
- Waste volumes expected to be incinerated
- Any local, State, or Federal permits or approvals
- Schedules and plans for complying with the approval requirements of this regulation.

Additional information may be required by the RA before deciding whether a Trial Burn is necessary. Ideally, this information would be included in the Initial Report, and would include:

- Chemical and physical characterization of the waste(s) to be burned
- Emission control system design and operating data
- Process control system operation
- Waste storage facilities description

If such additional information is not included in the Initial Report, it may be requested later. Requests for additional information must be restricted to the types of information which are consistent with the regulations at 761.40(d)(1)(i) through (1)(vii). If a waiver of any one of the requirements of 761.40(a) or (b) is being sought, the Regional Administrator can request information other then those types specified in 761.40 in order to make a determination as to whether or not an unreasonable risk of injury to health or the environment would result from the waiver. In addition, the Regional Administrator may request, 761.40(d)(3), any other information deem reasonably necessary to determine whether or not an incinerator may be approved.

This section is divided into seven subsections. Each deals with essential information contained in the Initial Report: incineration facility design, operational data capability, effluent monitoring capability, sampling location, waste characterization and feed rate, storage capability, and site-specific concerns. Table 14 is a checklist that may be used during the Initial Report evaluation process.

TABLE 14. CHECKLIST FOR EVALUATION OF INITIAL REPORT

Step	See Section	Information Supplied		
		Acceptable	Unacceptable	More Needed
Physical Properties of Waste	2.1.1.1			
Chemical, Thermodynamic Considerations	2.5			
General Site Plan Evaluation	4.1.1.1			
Waste Feed System Evaluation	4.1.1.2			
Thermal Destruction System Evaluation	4.1.1.3			
Pollution Control System Evaluation	4.1.1.4			
Process Control System Evaluation	4.1.1.5			
Operational Data Evaluation	4.1.2			
Effluent Monitoring Evaluation	4.1.3			
Sampling Locations	4.1.4			
Waste Characterization	4.1.5			
Storage	4.1.6			

4.1.1 Incinerator System Design

The PCB Regulations specify certain requirements for incinerator operations which are directly related to system design. A design evaluation must consider not only whether these requirements will be met but also whether good engineering practice is observed in system design and operation.

Aspects of incinerator system design which must be considered are not limited only to the incinerator unit. A systems approach to evaluation should be adopted. In evaluating a facility for approval to burn PCBs, general site plan, waste feed system, thermal destruction unit, pollution control system, and process controls should all be considered as they affect PCB destruction efficiency. Each of these topics is considered separately below.

4.1.1.1 General Site Plan Evaluation--

Overall facility design is dependent to a great degree on the type of waste which is processed. This will affect all aspects of waste processing, transportation and unloading, storage, pretreatment, feeding, combustion, gas cleaning and discharge, ash handling, and disposal, as well as health and environmental protection and safety. Compatibility of the incoming waste with processing equipment at the facility is of prime importance. The goal of the site plan evaluation should be to determine how well the various waste processing steps can be integrated, given the nature of the waste to be disposed of and the type and layout of equipment at the facility.

Ideally, the site plans submitted with the Initial Report should provide the following information:

- The size and location of all major process equipment and auxiliary structures
- Topographical information sufficient to analyze drainage patterns for storm runoff or liquid spills
- Facility boundaries and access routes

The evaluator should check to see that:

- The flow of waste through the facility is in a logical pattern which avoids unnecessary handling of PCBs and prevents their contaminating clean areas at the site

- The facility is contoured so that contaminated runoff or accidentally spilled liquids do not leave the property uncontrolled
- Security from vandalism is provided and access restricted to those persons who are directly involved with facility operations and who are knowledgeable of safe procedures for handling hazardous wastes.

4.1.1.2 Waste Feed System Evaluation--

As discussed below, the waste feed system includes all equipment used to process PCB wastes from their point of storage to the point at which they enter the incinerator. Since the feed systems for liquids and non-liquids are quite different, so they are separated for discussion. Discussion of automatic feed shut-off systems is reserved for Section 4.2.1.5.

4.1.1.2.1 Liquid feeding systems--Common unit operations in a liquid feed system are: 1) waste filtration, 2) waste/fuel blending, and 3) feed preheating. These operations are usually performed to obtain a liquid feed to the burners that has a low solids content, high heating value, and low kinematic viscosity.

Filtration may be necessary to remove suspended particles in the liquid which, if not removed, could clog, erode, or build up on the burner and degrade combustion efficiency. In-line filters may be used to reduce the solids content of the liquid. Several filters are usually installed in parallel.

Blending of PCBs with other fuels may be required when the waste PCB liquid has a relatively low heating value. Blending should be done in a closed-top agitated mixing vessel to prevent PCBs from splashing out.

Viscosity of the liquid can be decreased by heating. Steam heating with coils in the mixing tank, in-line heaters, and pipes wound with electrical heating cables are commonly used. As a practical maximum, 400-500°F is normally the limit for heating to reduce viscosity since difficulties in pumping can occur at high temperatures. Preliminary checks should be made to ensure that preheating will not cause polymerization, oxidation, nitration, or evolution of gas.

The vessels, pumps, and piping in the liquid feed system should be constructed of materials suitable for use in PCB service. Positive displacement (PD) pumps are preferred over centrifugal pumps because PD pumps afford a tighter shut-off and prevent siphoning when out of service. When PD pumps are used, a relief valve should be used downstream to prevent pressure buildup in the piping system. Discharge from the relief valve should be returned to a feed tank or the suction side of the pump. Sealed pumps, which have no external seals to leak, may be used. Sealed pumps are only available in a limited number of small sizes and generally have low efficiencies. However, in PCB disposal applications, their use may be justified.

The pumping and piping system should be designed to prevent any liquid leaks and to minimize the quantity lost if liquid does escape. Some guidelines for design are as follows:

- Indoor piping should be located either overhead or in floor trenches. Overhead installations should be near the ceiling or along the wall about 3 meters or more above the floor to prevent head injuries. Floor trenches should be impervious and should not drain to storm drains or sewers Metal plates should cover the trenches.
- Each pipeline should be labeled as to its contents
- Regular inspections of the piping system, as required by RCRA regulations, should be performed to check for leaks and determine the condition of system components.
- Pumps feeding the mixing tank should be located as near as possible to the storage tank.

4.1.1.2.2 Solid feeding system--Solid wastes may be fed pneumatically, mechanically, or by gravity to the incinerator. In most cases, PCB-containing solids will have to be reduced in size by shredding (or other method) for ease of feeding and efficiency of combustion. They must then be conveyed to the incinerator and charged to the combustion zone. These three operations - size reduction, transport, and charging - are discussed separately below.

PCB Items cannot usually be fed directly to an incinerator because they are too large to permit adequate combustion. The interior surfaces of PCB Items must be exposed to allow rapid vaporization of the PCBs in the waste. Shredding or hammermilling should be used to reduce the size and increase the surface area of the waste if pieces larger than about 4 cm are to be burned. Care should be taken in the size reduction operations to prevent escape of PCBs either from splashing or vaporization. Automatic operation is preferred so that plant personnel are not exposed to PCBs during the operation. Capacity of the size reduction equipment may exceed incinerator feed rate so that closed storage bins or silos may be required.

The method used for conveying solids from storage to the incinerator depends on the physical form of the feed material. Very often the material to be incinerated is packaged in fiber packs or drums which may be fed directly to the incinerator on an open conveyor belt. If the PCB-containing solids are not pre-packaged, screw or belt feeders may be needed. Screw feeders and belt feeders are common for handling hazardous wastes. Open belt feeders should not be used if the possibility exists for leaking of PCB liquids or spilling solids off the belt. Screw feeders are usually acceptable, except for sticky or cohesive materials.

Charging the incinerator may be done in either batch or continuous mode. Batch feeding may be accomplished by open charging or air-lock feeding. Open charging is often used in rotary kilns, where solids are gravity fed (e.g., from a conveyor belt) into a chute leading to the kiln. For batch air-lock feeding, the interior of the kiln is sealed from the outside by two sliding gates which operate alternately. A common method of continuous feeding is screw feeding solids into a stream of air which is blown into the incinerator. When feeding containerized PCB wastes, both waste and container may be incinerated. However, if only the contents of PCB Containers are emptied into the incinerator, the PCB Containers must be disposed of per the PCB Regulations. Disposal of PCB Article Containers is not regulated.

4.1.1.3 Thermal Destruction Unit Evaluation--

In evaluating the thermal destruction unit, checks should be performed to ensure that the unit is designed and operated so that:

- The various system components have sufficient capacity to handle the quantities of waste to be burned
- The temperature, residence time, oxygen concentration, and mixing achieved in the unit are sufficient to destroy PCBs

- Process controls incorporate automatic shutoffs to prevent waste flow if proper combustion conditions are not maintained

The first two considerations are discussed in this section, in general terms and specifically for systems designed to burn liquid and non-liquid PCBs. Process controls and automatic shutdown capabilities are discussed in Section 4.1.1.5.

4.1.1.3.1 General considerations--The capacity of an incinerator is governed by two factors: 1) the allowable heat release rate in the combustion chamber and 2) the maximum gas flow rate set by the design of the combustion equipment. If the amount of heat released (per unit time and chamber volume) exceeds the design capacity of the chamber, structural damage to the refractories will result. To evaluate the adequacy of combustion chamber design, the following procedures should be used:

- Determine the heating value and proposed feed rates for waste and auxiliary fuel, and calculate a heat release rate (Btu/hr).
- Determine combustion chamber volume and design heat release rate (Btu/hr-cubic foot).
- Compare heat release rates. If design rate exceeds proposed waste/fuel feed rate, unit can be assumed to operate below its thermal limit. If the converse is true, fuel/waste feed rate must be decreased.

For proper incinerator operation, the gas handling system must be able to move the entire volumetric flow rate of combustion gases while overcoming all pressure drops in the system. The prime gas mover in waste incineration systems is usually an induced draft fan located downstream of the air pollution control devices. Fan capacity will be specified by the fan manufacturer and will vary with pressure and fan inlet temperature.

The highest pressure drops across the system will occur in the pollution control devices. Smaller pressure drops will occur from frictional losses during gas flow through the incinerator and system ductwork. Major pressure drops can be determined from manufacturer specifications and gas flow rates at the inlets to each control device, or they may be known by facility operators from experience. Other pressure drops such as frictional losses through ducts and losses due to flow constrictions can be estimated using standard engineering methods (123).

An evaluation of gas moving capacity should include the following steps:

- Determine gas flow rate and temperature at the inlet to the induced draft fan.
- Estimate total pressure drop across the system.
- Compare fan capacity at the estimated pressure drop with expected gas flow rate. If fan capacity exceeds that needed to handle the expected gas flow, the system can be assumed to operate below its maximum gas handling capacity. If the capacity is insufficient, waste feed rate must be decreased, fan capacity increased, or the system must be modified to reduce pressure drop.

If means other than an induced draft fan are employed (e.g., steam ejectors) the same basic procedure of determining gas flows and pressure drops may be used.

Conditions under which gas handling capacity is exceeded during operations should be avoided. Such a condition may be quite obvious, characterized by puffs of smoke emanating from upstream of a flow constriction in the system ductwork. The cause may be inhomogeneous feed, in which case the problem is transitory, or a continuous problem such as indicated in step 3 of the above evaluation. Continuous puffing should not be permitted in the final approval.

Another general consideration is that all incinerators should be equipped with auxiliary fuel firing systems to heat them up to operating temperature prior to the introduction of PCB waste. Such a firing system may consist of separate burners for auxiliary fuel, dual-liquid burners, or burners equipped with a pre-mix system in which fuel flow can be gradually turned down as waste flow is increased after the desired operating temperature is achieved. The same types of fuel/waste feed systems are required if auxiliary fuel firing is needed during PCB combustion. Liquid burners, whether installed in a liquid injection or solid waste incinerator, must be aligned so as to avoid impingement on refractory walls and on other burner flames (in a multiple burner system).

4.1.1.3.2 Incinerators for liquid PCBs--In evaluating incinerators for destruction of liquid PCBs, the following points should be considered:

- Are the physical properties of the waste compatible with the burner type used?
- Have the chemical and thermodynamic properties of the waste been identified and are they compatible with incinerator design and operation?
- Can adequate excess air rate, temperature, residence time, and mixing be achieved and maintained to ensure required destruction efficiency?

Kinematic viscosity and the size and concentration of solids in a liquid waste must be considered in determining burner/waste compatibility. For good atomization, the liquid should have a low viscosity and a low concentration of solids. Kinematic viscosities greater than 750 SSU (Saybolt standard units) may cause incomplete atomization and result in smoke and unburned particle emissions. This is, however, only a rule of thumb since some burners can handle higher viscosity liquids, and others cannot handle liquids with this viscosity. Solids in the waste can cause problems by plugging, eroding, or building up on the burner. The concentration and the size in relation to the burner nozzle must be considered.

Atomization can be achieved by rotary cup atomization, single-fluid pressure atomization, or dual-fluid atomization using high or low pressure air or high pressure steam.

A rotary cup atomization burner consists of an open cup mounted on a hollow shaft. Liquid is fed through the shaft into the rotating cup where it spreads in a film toward the rim. At the rim, the centrifugal force of the rotating cup tears the film into droplets. High pressure air fed through an annulus on the shaft, aids in atomization and shaping the flame.

In air or steam atomizing burners, atomization can be accomplished by physical mixing of fuel and atomizing media inside or outside the nozzle or by sound waves set up by compressed gas and directed onto the liquid in the burner. Sonic atomization requires less waste pressurization and can effectively handle slurries and liquids with relatively large particles without plugging problems.

In evaluating a specific incinerator design the viscosity and solids content of the wastes should be compared with manufacturer specifications for the particular burner employed.

Chemical properties of the waste must be evaluated in order to calculate stoichiometric combustion air requirements and predict the composition and flow rate of combustion product gases. Complete combustion can be assumed for scoping calculations. Theoretical air requirements must be based on the elemental composition of the waste and any auxiliary fuel fired with the waste. Table 15 shows stoichiometric oxygen requirements and combustion products formed for complete combustion of the major elements expected in PCB wastes.

TABLE 15. THEORETICAL OXYGEN REQUIREMENTS AND PRODUCT GAS YIELDS FOR COMPLETE COMBUSTION

Waste/Fuel Component	Theoretical Oxygen Required	Product Gas Yield
Carbon	2.66 lb/lb carbon	3.66 lb CO_2/lb carbon
Hydrogen	7.94 lb/lb hydrogen	8.94 lb H_2O/lb hydrogen
Oxygen	-1.00 lb/lb oxygen	
Chlorine	-0.226 lb/lb chlorine	1.03 HCl/lb chlorine -0.254 lb H_2O/lb chlorine
Sulfur	0.998 lb/lb sulfur	2.00 lb SO_2/lb sulfur
Nitrogen (fuel)	--	1.00 lb N_2/lb fuel nitrogen
Nitrogen (air)	--	3.29 lb N_2/lb theor. oxygen
Water	--	1.00 lb H_2O/lb water

The combustion products in Table 15 are not the only species formed during combustion. Excess air, products of side reactions, and products of incomplete combustion will also be present. The most important of these are carbon monoxide (CO), oxides of nitrogen (NO_x), chlorinated organics (RCl), excess oxygen (O_2), and free chlorine (Cl_2). Monitoring of combustion emissions is required for all but free chlorine.

Chlorine formation results from an inadequate supply of hydrogen to convert the chlorine in PCBs to HCl. Free chlorine is more toxic and harder to remove by wet scrubbing than HCl, so that its formation is undesirable. The American Council of Governmental Industrial Hygienists has set a time weighted average (for 8-hour days, 40-hour weeks) for Cl_2 of 3 mg/m^3 or 1 ppmv (120). The amount of free chlorine formed can be estimated from equilibrium calculations using the following equations (8):

$$Kp = \frac{(P_{HCl})^2 \, (P_{O_2})^{\frac{1}{2}}}{(P_{H_2O}) \, (P_{Cl_2})}$$

$$\ln Kp = -\frac{7241}{T} + 8.292$$

where the terms in the equilibrium expression are the partial pressures, in atmospheres, of HCl, O_2, H_2O, and Cl_2 and the equilibrium constant Kp is a function of absolute temperature T (Kelvin). For highly chlorinated feeds, formation of free chlorine may be a problem. Increasing combustion temperature, decreasing excess oxygen, and increasing hydrogen content of the waste/fuel will lead to reduced free chlorine formation. Stoichiometrically, at least 0.0282 pounds of hydrogen are required to convert one pound of chlorine in the waste to HCl. Burning wastes containing sulfur may also help alleviate chlorine emissions. Sulfur dioxide formed during combustion is thought to reduce Cl_2 to the chloride (124).

The heating value of a waste must be considered in establishing an energy balance for the combustion chamber and in assessing the need for auxiliary fuel firing. To maintain stable combustion, the heat released by combustion must also heat incoming waste to its ignition temperature and provide the activation energy for oxidation reactions to occur. Wastes with heating values below 6,000 Btu/lb usually require auxiliary fuel.

Heating value should be reported as "higher', "lower" or "net". The higher heating value is greater than the lower heating value by the heat of vaporization of the water in the combustion products. The net heating value of a waste is its lower heating value minus the heat required to vaporize any moisture present. Since the net heating value represents the net energy input into the combustion process, net heating values are useful in developing energy balances for incinerators.

The heating value of a complex waste mixture is difficult to predict *a priori*. Therefore, these values should be measured experimentally. Approximate heating values for chlorinated chemical wastes such as PCBs are (8):

$$\text{Lower Heating Value, Btu/lb} = 14{,}000\,(C) + 45{,}000\,\left(H - \frac{O}{8}\right) - 760\,(Cl) + 4500\,(S)$$

$$\text{Higher Heating Value, Btu/lb} = 14{,}000\,(C) + 54{,}500\,\left(H - \frac{O}{8}\right) - 150\,(Cl) + 4500\,(S)$$

where C, H, O, Cl, and S are the weight fractions of the indicated elements in the waste.

For auxiliary fuels, the following net heating values are typical:

Residual fuel oil (e.g., No. 6) - 17,500 Btu/lb
Distillate fuel oil (e.g., No. 2) - 18,300 Btu/lb
Natural gas - 19,700 Btu/lb (1,000 Btu/scf)

Standard practice in the hazardous waste incineration industry is to blend wastes so that the chlorine content does not exceed about 35%. This is done to maintain sufficient heating value for sustained combustion, prevent excessive HCl formation, and to limit free chlorine concentration in the combustion gas.

Temperature, oxygen concentration, dwell time and the degree of mixing achieved in the combustion chamber are the major parameters affecting thermal destruction efficiency. Methods for evaluating these parameters in light of the current PCB Regulations are described in the following paragraphs.

PCB Regulations set the following criteria for destruction of liquid PCBs in an Annex I incinerator:

- Maintenance of the introduced liquids for a 2-second dwell time at 1200°C (± 100°C) and 3% oxygen in the stack gas, or
- Maintenance of the introduced liquids for a 1.5-second dwell time at 1600°C (± 100°C) and 2% oxygen in the stack gas.

In order to evaluate whether the incinerator can meet these criteria, it must be determined that:

- The waste, auxiliary fuel, and combustion air feed rates will result in maintenance of the gas temperature above 1100°C with 3% or greater oxygen concentration, or above 1500°C with 2% or greater oxygen concentration.
- The volume of the combustion chamber is sufficient to provide gas residence times of 1.5 seconds or greater at 1500°C or above, or 2 seconds or greater at 1100°C to 1500°C.

The amount of excess air needed for incineration of non-liquid PCBs depends on the degree of mixing achieved in the primary combustion zone, secondary air requirements, and combustion temperature. The theoretical (maximum) flame temperature is reached at zero percent excess air. Adding excess air dilutes product gases and reduces the temperature in the incinerator. Such a reduction in temperature is desirable when wastes with good combustion characteristics and high heating value are being burned in order to limit refractory degradation. When wastes with poor combustion characteristics or low heating value are being burned, excess air should be minimized to keep the combustion temperature high so that combustion chamber volume and downstream equipment size can be smaller.

Two excess air rates must be considered for liquid injection incinerators, primary combustion air and total excess air. Normally, 10% to 20% primary excess air is needed at the burner to prevent smoke and soot formation. This may be reduced to 5% for high efficiency burners firing homogeneous waste. Too much primary excess air (a condition which may result under turndown conditions) can blow the flame away from its retention cone. Burner manufacturer specifications provide the best source of information analysis. In general, the total excess air rate should exceed 20% to 25% to insure adequate waste/air contact in the secondary combustion zone (8).

The temperature/excess air evaluation procedure is based on identification of: 1) the minimum air-to-waste ratio (A/W) which will give the required 2% or 3% oxygen in the combustion product and 2) the maximum A/W that can be used and still obtain temperatures high enough to conform with regulatory requirements. Once these maximum and minimum ratios are calculated, the ability of the unit to operate satisfactorily within this range of conditions must be assessed. The evaluation procedure requires calculation of mass and energy balances around the combustion chamber, which should be based on a unit mass of a waste/auxiliary fuel mixture of known (or estimated) composition and heat content.

To calculate the minimum A/W:

- Calculate - From the known (or estimated) composition of the waste and auxiliary fuel, calculate the yields of combustion product gases assuming complete combustion with theoretical air (see Table 15). Check mass balance.
- Calculate - Assuming oxygen concentrations of 2% and 3% (by mole or by volume) in the combustion product gases, back calculate the required combustion air mass flow rate (do not neglect the nitrogen present with excess oxygen). Check mass balance. This is the minimum A/W.
- Calculate - Set up the energy balance around the combustion chamber for the minimum A/W determined above. The enthalpy changes (ΔH) to be considered in the energy balance are as follows (all values of $\Delta H > 0$):

$$\Sigma\Delta H \text{ (products)} = \Sigma\Delta H \text{ (reactants)} + \Delta H \text{ (combustion)} - \Delta H \text{ (heat loss)}$$

Sensible heat of Products above standard temperature	=	Sensible heat of reactants often negligible, especially if reactants are not preheated	+	Net heating value	Assume $\sim$5% of total heat released is lost through walls of chamber

- Calculate - Determine the maximum flame temperature (T_F) which can be achieved at the minimum A/W. This will require an iterative solution of the energy balance for T_F.
- Evaluate - Can the required minimum combustion air flow (primary and secondary) be supplied by existing equipment over the range of expected waste/fuel feed rates?
- Evaluate - Is the unit capable of withstanding the temperature and heat release rate at the minimum A/W?

Once the minimum A/W has been evaluated, the maximum A/W which will still result in maintenance of the desired combustion temperature should be calculated.

- Calculate - Set up the energy balance around the combustion chamber assuming a flame temperature and leaving the excess air rate as variable.
- Calculate - Find the excess air rate required to attain the assumed T_F. A direct solution can be found. This is the maximum A/W for the assumed T_F.
- Evaluate - The burner(s) should be able to operate satisfactorily at or below this maximum A/W and should not be operated above it. Include in the evaluation both maximum waste/fuel flows and turndown conditions which may cause operation at A/W higher than full load.

Dwell time, θ, is a function of combustion chamber volume, V and combustion gas flow rate, Q. The latter is also a function of temperature, and since $\theta = V/Q$, the higher the temperature the shorter the dwell time. By assuming a maximum temperature, a minimum dwell time can be calculated. The maximum temperature in the combustion process is the flame temperature. The Initial Report should give a value for V, total combustion chamber volume. The minimum dwell time can then be calculated at the flame temperature from knowledge of the volumetric flow rate of combustion gases (calculated assuming complete combustion or from actual gas flow measurements). If the minimum dwell time from this calculation exceeds 1.5 seconds at 1500°C, or above, or exceeds 2 seconds at 1100°C to 1500°C and if the chamber outlet temperatures also exceed the cutoff temperatures (1100°C and 1500°C), the residence time can be considered adequate.

If the temperature at the combustion chamber outlet is known, this temperature can be used to calculate a maximum dwell time in the chamber. Since the outlet temperature is the lowest temperature in the combustion chamber, the dwell time calculated is a maximum dwell time. If the maximum dwell time calculated is less than 1.5 seconds at 1500°C, or above, or less than 2 seconds at 1100° to 1500°C, and if the outlet temperature is less than the cutoff temperatures, the dwell time is not sufficient. However, if the outlet temperature exceeds the cutoff temperature, sufficient dwell time may exist downstream of the combustion chamber to meet the requirements of the PCB Regulations. If successive downstream temperatures above the cutoff temperature are known (along with cumulative system volumes), additional upper limit dwell times may be calculated. Approximate mean dwell times may then be calculated based on the average of the flame temperature and the downstream temperature (which is above the cutoff temperature). The approximate mean dwell times so calculated can then be compared to those required by the regulations.

Temperature, oxygen, and residence time requirements for waste destruction all depend to some extent on the degree of mixing achieved in the combustion chamber. However, mixing is difficult to quantify. Manson and Unger (116) have attempted to define the relationships among these parameters in some incinerator types by comparison of dimensionless quantities, such as the Fourier and Biot numbers. Such analysis based on design data may be useful in comparing mixing in two incinerators of the same type. To some extent, operational data, such as the CO and total hydrocarbon emissions from an incinerator provide some measure of mixing efficiency. Performance data from prior tests may be compared to data for incineration of similar wastes in a unit of the same generic type as the one being evaluated. Design data for the unit can also be used as the basis for a cursory evaluation. Such an evaluation should be made to ensure that turbulent flow conditions exist in the combustion chamber.

In liquid injection incinerators the calculation of Reynold's number (see Section 2.1.1.5) can be simplified to consideration of superficial gas velocity only. Adequate turbulence is usually achieved at superficial gas velocities (v) of 3 to 5 m/s, determined by

$$v = \frac{q}{A}$$

where q = gas flow rate at operating temperature, m^3/s
A = cross-sectional area of the incinerator chamber, m^2

If primary or secondary air is fed tangentially or if cyclonic flow prevails in the incinerator, actual gas velocities will be greater than v. In these cases, adequate turbulence may be achieved at $v < 3$ m/s. Baffles installed in the secondary combustion zone can increase turbulence by changing the direction of gas flow. However, baffles increase pressure drop and are for this reason not commonly used in liquid injection incinerator designs.

Steam ejectors can also be used to increase turbulence.

4.1.1.3.3 Incinerators for non-liquid PCBs--Thermal destruction units designed to destroy non-liquid PCBs will generally employ a primary combustion zone where solid wastes are heated, volatilized, and partially oxidized and a secondary combustion chamber (afterburner) to complete the gas-phase combustion reactions. Liquid wastes may be fired in the primary combustion zone along with waste solids. The afterburner is normally a liquid injection incinerator, firing auxiliary fuel and/or waste.

The discussion in this section will center on the design of the primary combustion zone for solids. However, in evaluating the design of an incineration system for solids, the afterburner should be evaluated according to the principles outlined in Section 4.1.1.3.2. Approval to burn non-liquid PCB wastes should only be granted to a facility if both the primary combustion zone and the afterburner are suitable for PCB incineration.

The same basic considerations used to evaluate incinerators for liquid PCBs can be applied to the evaluation of incinerators for non-liquid PCBs. These considerations are: physical waste properties, chemical/thermodynamic waste properties, combustion temperature, excess air, residence time, and mixing. They are discussed below for the two generic types of incinerators deemed most suitable at this time for incineration of non-liquid PCBs: rotary kiln and multiple hearth incinerators.

Compatibility of the incinerator with the physical form of the waste is an important consideration. Rotary kilns are very versatile. They can handle most slurries, sludges, bulk solids, and containerized wastes. However, several wastes do present some problems when charged to a rotary kiln. Aqueous organic sludges that become sticky when dried form rings around the circumference of the kiln, disrupting the flow of solids. Glass tends to become a molten mass in the kiln which can impair solids flow and can be difficult to remove. Solids such as drums that can roll down the kiln may not be retained as long as the rest of the solids. This last problem can be reduced by not introducing drums into an empty kiln, so that solids already in the kiln can arrest the rolling action of the drums. In multiple hearth incinerators, the physical form of the solids must not interfere with the action of the rabble arms that move the solids from hearth to hearth. Multiple hearth incinerators are not as well suited as rotary kilns to receive large bulk solids. Multiple hearth units were originally designed to incinerate sludges. They perform best with sludges and/or granular solids. Hammermilled, drained PCB Small Capacitors may be suitable as a multiple hearth feed.

The chemical and thermodynamic considerations applicable to incineration of non-liquid PCBs are essentially the same as for liquid PCBs. A greater problem with non-liquid wastes is feed inhomogeneity. Such inhomogeneity (e.g., from feeding large containers of PCB wastes to rotary kilns) can cause rapid evolution of combustion product gases, and a consequent positive pressure surge. Such violent pressure swings can cause problems in design of the process control system. They may also lead to buildup of pressure in the kiln (normally operated at subatmospheric pressure) to exceed atmospheric pressure for brief periods. Release of kiln gases, containing unburned PCBs and possibly PCDFs would occur under these conditions. In addition to inhomogeneity, the other major problem related to the chemical properties of PCB waste concerns materials of construction and their ability to withstand the corrosive attack of HCl at high temperature. Multiple hearth incinerators, which use moving internal metal parts, would require frequent inspection and maintenance when burning PCBs.

Excess air rates for incineration of non-liquid PCBs must be greater than for liquid PCBs because mixing of the air and solids is not as intimate as mixing of air and atomized liquid droplets. The actual excess air rate will depend on the heat content of the waste, the desired combustion temperature, and the degree of air/waste mixing. For PCB burns in rotary kilns at RES and ENSCO (see Section 2.2.1.1), excess air rates measured in the duct downstream of the afterburners ranged from about 85% to 100%. Multiple hearth incinerators processing sewage sludge generally operate with 50% to 100% excess air (125). An additional guideline is that enough air should be supplied to the kiln or multiple hearth to prevent oxygen-deficient conditions which may give rise to PCDFs. That is, the primary combustion zone should not act as a pyrolyzer or starved air combustor relying on the afterburner for PCB destruction. Experience with a particular waste/incinerator combination is the best guideline for determining an adequate excess air rate. As with liquid injection incinerators, the equipment supplying combustion air should have sufficient capacity to handle the expected air flow. Excess air rate should be low enough to allow maintenance of adequate temperature in the system but high enough to prevent thermal damage to system hardware.

Temperature and dwell time requirements for incineration of non-liquid PCBs are not prescribed directly by the PCB Regulations. Assuming non-liquid PCB incinerators will incorporate an afterburner, the function of the primary combustion zone (i.e., rotary kiln, multiple hearth) is to volatilize, partially oxidize, or otherwise convert all organic components of the waste to a gaseous state. Therefore, temperatures and residence times do not necessarily have to be sufficient for PCB destruction, only PCB volatilization. The speed of the volatilization step (for a given temperature and residence time) is proportional to the initial size of the PCB solids fed. Thus, smaller sized feeds should require less dwell time. In general, for feed material sized to less than about 4 cm, the incinerator should be capable of retaining solids for 15 minutes to one hour at 800°C (8).

Rotary kilns can easily meet these criteria. Multiple hearth incinerators can meet the dwell time criterion, and can probably operate at high enough temperatures. Three operating zones are usually used in multiple hearth furnaces for incinerating sewage sludges:

- The top hearths constitute the drying zone, in which gas temperatures average about 420°C and solids temperatures about 70°C. Here, cool solids are heated by hot gases.
- The middle hearths constitute the incineration zone, in which gas and solid temperatures range from 760°C to 980°C.
- The bottom hearths constitute the cooling zone, in which gas temperatures average about 180°C and solids temperatures about 250°C. Here, hot solids heat incoming combustion air.

For rotary kilns, the following equation can be used to estimate solids retention time (123):

$$\theta_S = 0.19 \frac{(L/D)}{(S)(N)}$$

where θ_S = retention time for solids, minutes

L,D = kiln length and inside diameter, meters

S = slope of kiln, meters/meter

N = kiln rotational speed, revolutions per minute

Gas residence times for rotary kilns and multiple hearth furnaces can be estimated assuming plug flow as with liquid injection incinerators. However, this does not take into account that gases are continuously being evolved along the entire length of the combustion chamber and are not introduced only at one end. Thus, a wider distribution of dwell times exists for non-liquid PCB incinerators than for liquid injection incinerators. Solids residence time for multiple hearth incinerators is difficult to calculate from purely a design standpoint and is usually determined experimentally. It depends on feed rate, shaft rotational speed, and the spacing, angle, and size of the rabble teeth. Operator experience and manufacturers specifications are the best guide to the solids residence time achieved in multiple hearth units. Gas residence time in afterburners should be evaluated using procedures and guidelines for liquid injection incinerators.

Mixing of air and solids in rotary kilns is primarily a function of the rotational speed of the kiln. Typical rotational speeds are in the 0.3 to 1.5 m/s range, measured at the kiln periphery. The rotation of the kiln segregates the charge so that the large solid particles are at the top of the charge (in contact with the gas phase) and the small particles are at the bottom. Gas and charge move cocurrently (some cement kilns are a notable exception). For comparing mixing characteristics of two kilns (firing similar wastes), the parameters of interest are rotational speed, superficial gas velocity, and charge depth (related to L/D and feed rate). In multiple hearth incinerators, rotating rabble arms on each hearth provide mixing action as well as rotary and downward movement of the charge. In travelling across a hearth, solids are constantly turned and broken into smaller particles by the rabble arms, exposing a large surface area to the hot gases. The rabble arms form spiral ridges of solids on each hearth, the surface area of which varies with the inherent angle of repose of the solid. The exposed surface area is thus greater than the total hearth area. Effective surface area can be as great as 130% of the total hearth area (125). Added mixing is achieved due to the fall of the sludge from hearth to hearth through the coutercurrent flow of hot gases. Quantification of mixing parameters is difficult and can best be based on prior experience with similar waste/incinerator combinations.

4.1.1.4 Pollution Control Systems Evaluation--

The major gaseous pollutant arising from combustion of PCBs is hydrogen chloride, HCl. Combustion of solids gives rise to particulate emissions which must be controlled. PCB Regulations mandate the use of wet scrubbers or an approved alternate method for HCl control. Performance requirements are to be specified by the appropriate RA. Additional hazardous waste regulations pursuant to RCRA also apply to solid waste products of PCB incineration.

Three steps are required in an evaluation of the air pollution control system. The type, design, and operation of the installed equipment must be evaluated to answer the following questions:

- Is the type of pollution control equipment installed at the facility capable of controlling HCl and particulate emissions expected from the incinerator?
- Is the equipment properly designed to handle the particular waste streams produced from combustion of PCBs?
- Will the proposed operating conditions of the control device(s) assure adequate control of emissions?

A fourth step in an overall systems approach to the pollution control evaluation should consider ultimate disposal of scrubber water and ash. All four of these steps are discussed separately below.

4.1.1.4.1 Equipment selection--Equipment commonly used for gaseous and particulate emission control includes wet scrubbers, electrostatic precipitators, and fabric filters. In hazardous waste incineration facilities designed to handle a variety of solid and liquid wastes, the use of wet scrubbers (venturi and packed bed) is most common (see facility descriptions in Section 2.1). In the future, new control technologies such as wet electrostatic precipitators, electrostatically augmented scrubbers, and dry collection on fabric filters with chemical additives may be used in special applications or as secondary devices to polish gas streams treated by conventional methods. The selection of the air pollution control device should be based on the physical and the chemical chemical characteristics of the incinerator off-gases. In general:

- Wet scrubbers (packed bed, tray (plate) tower, venturi) are most suitable for the removal of HCl. For gas streams also containing high particulate loadings venturi scrubbers are necessary.

- Electrostatic precipitators are effective for the collection of fine particles, are unable to remove HCl, and perform poorly for particles with high resistivity.
- Fabric filters are effective for the collection of fine particles, unable to collect HCl, and perform poorly with particles that are hygroscopic, sticky, or have the tendency to solidify on fabric material.

Control devices can be categorized as either wet or dry devices. Each has advantages and disadvantages. Dry control devices (cyclones, electrostatic precipitators, and fabric filters) have the advantage of particulate collection without production of sludge or wastewater. They are generally effective for removing five particles (less than 1 µm diameter) at low to moderate pressure drop (less than 2 k Pa). However, most are ineffective in removing gaseous pollutants, such as HCl. Wet scrubbers can simultaneously remove particulate matter and gaseous pollutants but produce sludge and wastewater streams which require treatment and disposal. Wet control devices operate at moderate to high pressure drop to attain particle cut diameters (diameter of particles collected with 50 percent efficiency) in the 0.3 to 1 µm range.

Potential configurations of air pollution control devices for hazardous waste incinerator facilities are presented in Table 16. Low particulate loadings indicate levels typically associated with liquid injection incinerators, while high particulate loadings indicate levels associated with solid waste incinerators.

Most hazardous waste incineration facilities currently employ one or more of the wet scrubber designs shown in Figure 20. Venturi scrubbers or sequential venturi and plate type or packed bed scrubbers are quite common. For systems incorporating venturi scrubbers, a gas quench is optional since the venturi effects gas cooling. Such systems can handle a variety of incinerator off-gas compositions and dust loadings. Systems not incorporating a venturi scrubber require a quench section prior to a caustic or lime scrubber, otherwise the hot gases cause particulate formation in the scrubber. Since wet scrubbers have found the widest application in hazardous waste incineration, both for gaseous and particulate control, their design and operational characteristics will be emphasized in the following discussions. As experience is obtained with wet electrostatic precipitators, sorbent-

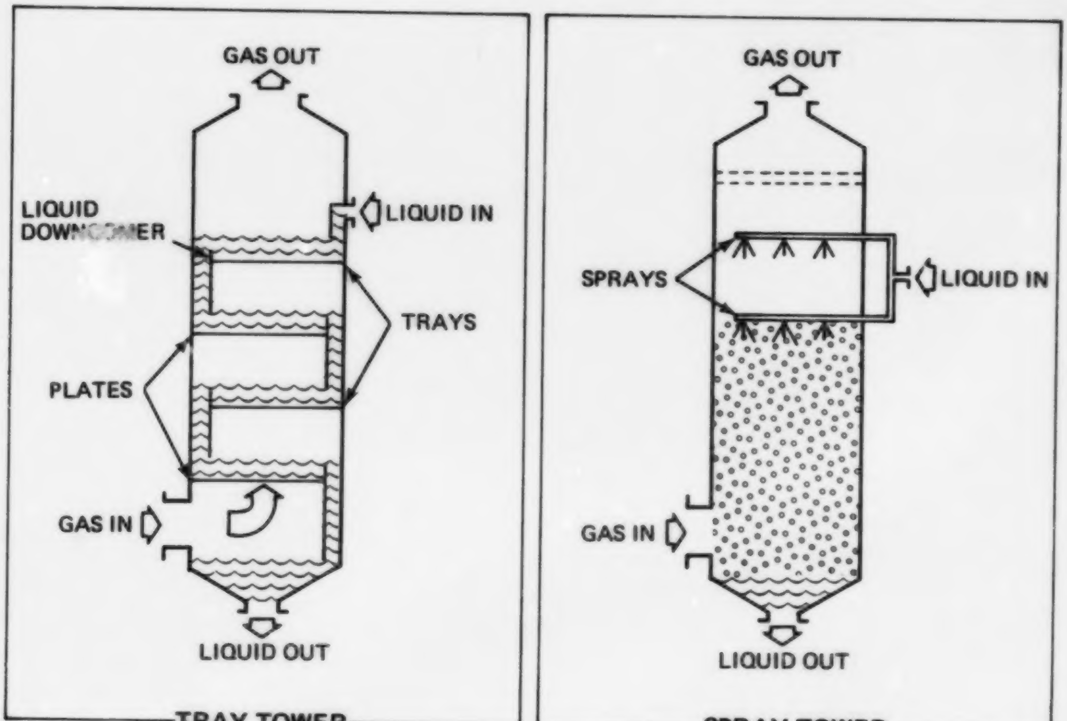
TABLE 16. CONFIGURATIONS OF SELECTED GAS CLEANING DEVICES APPLICABLE TO PCB INCINERATION FACILITIES

Gas Stream Characteristics		Particulate Control Device*	HCl Control Device
No HCl Control Required	High or low particulate loading	Cyclone Electrostatic Precipitator Fabric filter	Not required
		Gas-atomized spray †# Preformed spray	Not required
		Wet electrostatic precipitator	Not required
HCl Control Required	High or low particulate loading	Cyclone Electrostatic precipitator	Gas-atomized spray # Preformed spray # Plate type scrubber # Packed bed scrubber #
			Sorbent filled baghouse Ionizing wet scrubber
		Gas-atomized spray † Preformed spray	Plate type scrubber (optional) †# Packed bed scrubber (optional) †#
			Sorbent filled baghouse (optional) Ionizing wet scrubber (optional) Wet electrostatic precipitator (as a polishing device)
HCl Control Required	Low particulate loading	Plate type scrubber †# Packed bed scrubber †#	Not required
		Ionizing wet scrubber	Not required

* Particulate control may require combinations of the indicated devices depending on loading, size distribution and economics.

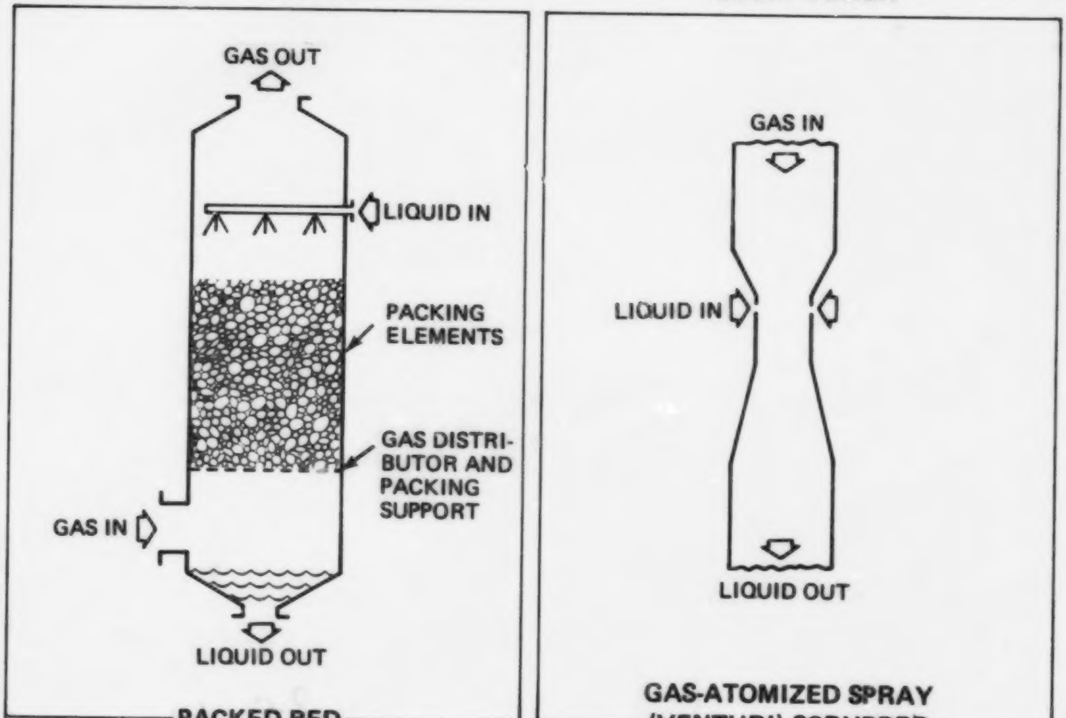
† Existing hazardous waste incineration facilities commonly employ these device configurations.

# Mist eliminator is required for this device but is optional if two wet scrubbers are used in series.


GAS OUT
LIQUID IN
LIQUID DOWNCOMER
TRAYS
PLATES
GAS IN
LIQUID OUT
GAS OUT
SPRAYS
LIQUID IN
GAS IN
LIQUID OUT

TRAY TOWER

SPRAY TOWER


GAS OUT
LIQUID IN
PACKING ELEMENTS
GAS DISTRIBUTOR AND PACKING SUPPORT
GAS IN
LIQUID OUT
GAS IN
LIQUID IN
LIQUID OUT

PACKED BED

GAS-ATOMIZED SPRAY (VENTURI) SCRUBBER

Figure 20. Examples of wet scrubber types for emission control.

filled baghouses, and other novel devices, these systems will find wider application. Should the need arise to evaluate these systems, technical assistance should be requested from equipment suppliers and/or the EPA Industrial Environmental Research Laboratory, Research Triangle Park, North Carolina.

The selection of wet scrubber types for different incinerator types can be summarized as follows. Plate towers, packed beds, and venturi scrubbers can all be used to control HCl emissions from liquid injection incinerators. Because of its lower operating costs (due to lower pressure drops), the packed bed scrubber is used at most liquid injection incineration facilities. Packed beds and plate towers are generally more effective than venturi scrubbers in reducing HCl emissions but less effective in controlling emissions of acid mists. For solid waste incinerators, high particulate loadings preclude the use of plate towers or packed beds as the primary control device. The venturi scrubber is used in this case for simultaneous gaseous and particulate emission control A tray tower or packed bed used downstream of a venturi scrubber serves two functions: it eliminates liquid droplet entrainment and further reduces emissions of gaseous pollutants such as HCl.

4.1.1.4.2 Design considerations--The major factors which must be considered in the design of wet scrubbers include: 1) total gas flow rate, 2) gas inlet temperature, 3) type and concentration of gaseous pollutants to be removed, 4) particulate loading and size distribution, 5) desired removal efficiency for gases and particulates, 6) corrosiveness of contaminants, and 7) variations in physical and chemical characteristics of the gas stream to be treated.

The flow rate of gas to the scrubber is dependent on the feed rate and composition of hazardous waste and fuel and the amount of combustion air used. The size of and gas velocity through the control devices is directly related to the gas flow rate. Most control devices have an optimum velocity range, above or below which performance decreases. For example, in absorption towers higher gas velocity decreases the mass transfer resistance but may also cause decreased performance due to channeling or flooding.

Temperature, by its effect on gas volume, has an impact on the size and cost of control devices. Temperature also influences the selection of materials of construction for these devices. For example, high gas temperatures may require the use of special refractory linings. Many times gas temperatures are lowered to 65-100°C (150-200°F) by water or solution quenching, so that control equipment downstream can be constructed of fiberglass reinforced plastic (FRP).

Wet scrubbers must be designed to remove HCl present at relatively low levels (less than 10%) in the gas stream. Scrubber liquids commonly used to remove HCl include water, caustic (NaOH) solution, and lime slurry. Based on cost considerations, lime is preferred, even though its incomplete solubility in water sometimes poses operational and disposal problems.

Packed bed scrubber design is based on mass transfer considerations. Required packing depth can be estimated by the following equation (126):

$$Z = N_{OG} \times H_{OG}$$

where Z is the packing depth, N_{OG} is the number of overall transfer units and H_{OG} is the height of a transfer unit. The number of transfer units is related to the desired removal efficiency. The height of a transfer unit is related to the mass transfer rate and is dependent on the size and type of packing, gas and liquid flow rates, and the chemistry of the gas/liquid system. For low concentrations of HCl, absorbed by a solution in which it can completely dissolve or react, the expression for N_{OG} is approximated by:

$$N_{OG} = \ln\left(\frac{y_1}{y_2}\right)$$

where y_1 and y_2 are inlet and outlet concentrations of HCl, respectively. Thus for 99% removal, $N_{OG} = \ln 100 = 4.6$; for 99.9% removal $N_{OG} = \ln 1000 = 6.9$; etc. The height of a transfer unit is quite difficult to calculate, however for gaseous contaminants that are highly reactive with the scrubbing liquid, H_{OG} is typically in the range 0.3 to 0.5 meters (127), depending on the type of packing used. Assuming HCl is present in low concentrations and is reactive with the scrubbing solution, required packing depth can be calculated as a function of packing size and removal efficiency. This has been done in assembling Table 17, which is based on data from Hanf and

MacDonald (127) for packing size vs. H_{OG}.

TABLE 17. PACKING DEPTH REQUIRED TO ACHIEVE SPECIFIED REMOVAL EFFICIENCY* (127).

Removal Efficiency	Packing Size				
	1 in.	1-1/2 in.	2 in.	3 in.	3.5 in.
90%	0.76 m	0.99 m	1.14 m	1.75 m	2.13 m
95%	0.91 m	1.14 m	1.37 m	2.06 m	2.59 m
98%	1.22 m	1.52 m	1.83 m	2.74 m	3.43 m
99%	1.40 m	1.75 m	2.13 m	3.12 m	3.96 m
99.5%	1.60 m	1.98 m	2.44 m	3.66 m	4.50 m
99.9%	2.13 m	2.67 m	3.20 m	4.80 m	6.02 m
99.99%	2.82 m	3.51 m	4.27 m	6.40 m	7.92 m

* Applicable only to gaseous contaminants that are highly soluble or chemically reactive with the scrubbing liquid. Variations in packing depth vs. the type of packing used (approximately ± 25 to 30%) have not been taken into account.

To design tray towers for absorption of gaseous contaminants that are highly soluble or chemically reactive with the scrubbing liquid, the number of actual trays N_T may be calculated from the equation:

$$N_T = - \frac{\ln(y_1/y_2)}{\ln(1-E_{MV})}$$

where y_1 and y_2 are the inlet and outlet concentrations of the gaseous contaminant and E_{MV} is the Murphree vapor phase efficiency. In deriving this equation, it is assumed that E_{MV} is identical for each tray in the tower. The Murphree vapor phase efficiencies for various tray designs may be obtained from published data for selected gas-liquid systems (123,126). Efficiencies normally range from 25 to 80%. For a 99% removal efficiency, the number of actual trays required would range from 3 to 16. A rigorous estimation of the Murphree vapor phase efficiency is extremely complicated, but in the case of absorption towers operating with low-viscosity liquids and without excessive weepage (liquid dripping) or entrainment, the estimates in Table 18 can be used.

TABLE 18. MURPHREE VAPOR PHASE EFFICIENCY FOR PLATE TOWERS (127)

Perforation Diameter	Murphree Vapor Phase Efficiency
1/16 in.	80%
1/16 to 1/8 in.	75%
1/8 to 3/16 in.	70%
1/4 to 3/8 in.	65%

The design of preformed spray and gas-atomized spray scrubbers for removal of gaseous contaminants is usually based on experimental data. No satisfactory generalized design correlation for these types of scrubbers exists, particularly when absorption with chemical reaction is involved. Reliable design must be based on full-scale data or at least laboratory- or pilot-scale data.

Tray towers and packed bed scrubbers are often interchangeable with regard to performance. However, each type has relative advantages and disadvantages over the other (126).

- For gases containing corrosive contaminants, construction of packed bed scrubbers is simpler than tray towers built of acid-resisting alloys. Also, the packing material can be readily changed to handle different kinds of corrosive fluids.
- The depth of packing in packed beds can be changed if a different removal efficiency is required or if the gas flow rate or wastes incinerated change. There is usually no flexibility in changing the number of trays in a tray tower.
- Unless operated at very high L/G ratios, the pressure drop in packed bed scrubbers is considerably lower than in tray towers designed for the same duty.
- For scrubbers less than about 1 to 1.5 m in diameter, capital costs for packed beds are usually lower than for tray towers. For larger equipment, plate towers are considered more economical.
- Tray towers are less likely to clog and can be more easily cleaned of accumulated particles than packed beds.
- Gas and liquid channeling are not encountered in tray towers.

Wet scrubbers can be effective in removing particulate matter as well as HCl emitted from the incinerator. Venturi and orifice scrubbers are the most commonly used wet scrubbers for particulate control. Although some particulate control is achieved with packed beds and tray towers, these scrubbers cannot handle gas streams with high particulate loadings. The inlet particulate size distribution is important in determining the overall collection efficiency of a particulate control device. A common method of representing particle size distributions is by plotting particle size versus cumulative percent of particles by weight that are less than a stated size. Presentation of such data on logarithmic probability paper often yields essentially straight plots, which characterize a log-normal distribution. Since log-normal distributions are defined by the mass median particle diameter (d_{pg}) and the geometric standard deviation (σ_g), this represents a concise method of data presentation.

Calvert, et al. (129) presented working plots of overall penetration versus the ratio of the cut diameter (diameter with 50% penetration, d_{50}) to mass median diameter with geometric standard deviation as a parameter. Figure 21 may be utilized to estimate overall penetration for tray, packed bed, and venturi scrubbers from cut diameter and particle size distribution data. Alternatively, the required cut diameter may be estimated from size distribution data and desired removal efficiency.

Consider the following example for particulate removal by a venturi scrubber. Assume the particulate matter being emitted from the incinerator has a mass median diameter of 4 μm and a geometric standard deviation of 3 μm. Using Figure 23, a venturi scrubber with a cut diameter of 0.5 μm (d_{50}/d_{pg} = 0.125) will have an overall penetration of 0.037. The overall removal efficiency will therefore be 96.3%. If only 90% removal is required, Pt = 0.1 and d_{50}/d_{pg} = 0.22. A design cut diameter of about 0.88 μm will provide the desired performance.

Hesketh (130) developed an empirical relationship between penetration of <5 μm diameter particles and pressure drop across venturis based on data from the collection of a number of industrial dusts. Assuming that particles larger than 5 μm are collected with 100 percent efficiency, the following equation may be used with size distribution data to estimate overall penetration:

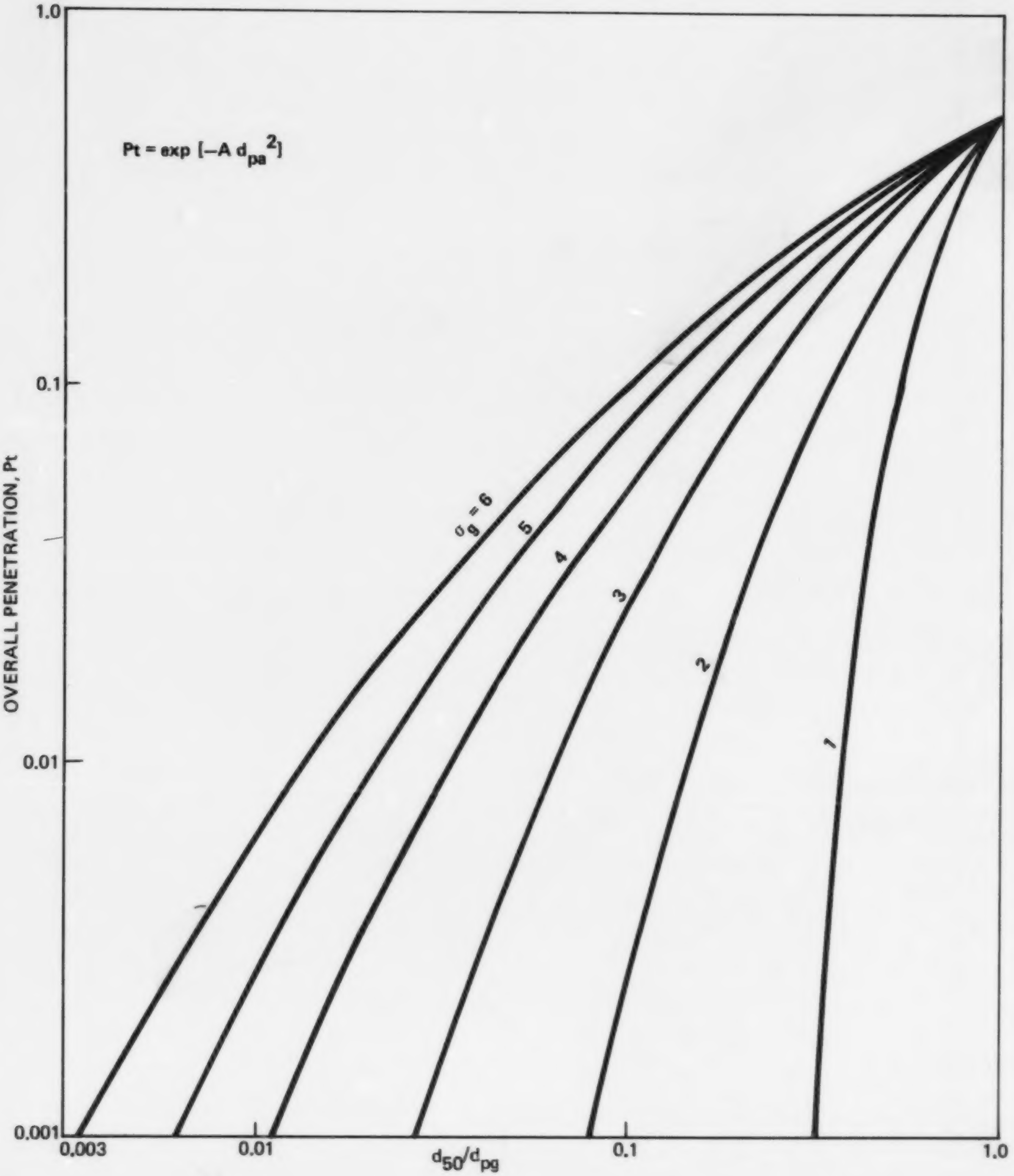


Figure 21. Overall penetration versus cut to mean particle diameter ratio (129)

$$Pt = 1.78 \times 10^{-4}(W)(\Delta P)^{-1.43}$$

where:

> W is the weight fraction of inlet particles 5 μm or less in diameter and ΔP is pressure drop in inches of water.

Materials of construction must be selected to resist corrosive and erosive attack from the HCl and particulates present in combustion product gases. Some of the corrosion problems with HCl can be alleviated by using basic scrubbing solutions and/or neutralizing scrubber effluent prior to disposal. However, experience has shown that neutralization is often not sufficient to prevent attack of hydrogen and chloride ions on materials. Investigators from 3M (131) report that dealkalinization of scrubber solutions worsens the effect of HCl. They note that as the pH of scrubber water decreases, the natural alkalinity of the solution shifts from the carbonate form to carbon dioxide. The high temperatures in the gas stream combined with turbulent contact of the gas and liquid phases causes the carbon dioxide to vaporize from the liquid. This dealkalinization decreases the buffer capacity of the scrubbing solution. Without buffering, chloride attack on metals and refractories is increased. Addition of soda ash (sodium carbonate) was proposed to restore buffer capacity but was not adopted due to high chemical costs.

Most efforts to combat corrosion have centered on selection of appropriate materials to resist attack by HCl. Field corrosion tests (132) conducted on a scrubber system for a chemical waste incinerator have shown that carbon steel, stainless steel, and Monel all experienced severe corrosion problems and are not recommended as materials of construction for scrubber systems, unless linings are used. Hastelloy C and Inconel 625 showed excellent resistance to pitting and crevice corrosion which can be attributed to their high molybdenum content.

Because of the corrosion problems associated with HCl, superalloys or non-metallic materials are used in scrubber construction wherever possible. In the quench section where temperatures of approximately 1000°C are encountered, Hastelloy C and Inconel 625 have been used. Other possibilities include refractory-lined carbon or stainless steel. Carbon graphite or acid resistant refractories installed with a furan resin cement have been used.

However, quench spray nozzles should still be made of Hastelloy C or Inconel 625.

For the scrubber, Hastelloy C or Inconel 625 can be used, but at temperatures <100°C, temperatures, fiberglass reinforced plastic (FRP) is recommended. It is economical, easily fabricated, lightweight, and has good resistance to both acid and alkaline environments, up to temperatures of around 100°C. Polyvinyl chloride (PVC) can be considered as a material for scrubber construction, but its use is limited to temperatures of less than 70°C. If structural strength becomes a prime consideration (e.g., for large scrubbers) carbon steel or stainless steel can be used with a suitable lining material. In such a case, bonding of the liner to the steel shell is a key factor in determining performance. Carbon graphite, FRP, Kynar, and acid resistant bricks and resins are suitable liner materials. Butyl rubber has been used, but acid and water vapor can penetrate thin (1/8 inch) rubber liners. Rubber is recommended only in applications where it is subjected to low gas velocities and is constantly flushed with water. In packed beds, ceramic, carbon, or plastic packing which can withstand acid attack is recommended.

Downstream system parts such as the induced draft fan and stack must also be protected from acid attack. Fans constructed of Hastelloy C usually resist most types of corrosion; however, fan vibrations can lead to fretting corrosion which enlarges the hub-to-axle clearance. Water sprays directed at the fan help in this regard. Stack coatings of fiberglass or resins are usually sufficient to prevent serious corrosion problems.

Erosion from attack by high velocity particles is a problem with venturi scrubbers. Throat and elbow areas are subject to the most wear. FRP does not stand up well in these regions. Harder materials are recommended; however, since no material is immune to erosion, areas of high wear should be designed for ease of replacement.

Cyclic incinerator operation may occur in systems burning solid wastes or sludges, particularly if drums or packs of waste are charged without shredding. Fixed bed incinerators may have a programmed incineration cycle that includes heating, charging, combustion, cool down, and ash removal. Such operation may affect the performance of scrubber systems. The magnitude of this potential impact will depend on the magnitude of the incineration cycle and the flexibility of the scrubber system. Control devices such as variable orifice venturis and flooded disk scrubbers afford considerable flexibility in both gas and liquid flow rates; however, only the liquid flow rate may be varied in fixed orifice devices and packed towers. Such systems may operate at less than optimum performance during portions of the incineration cycle. The potential for cyclic operation is, therefore, a significant parameter which must be incorporated into the selection and design of a particulate emission control device.

4.1.1.4.3 Operation and maintenance--Proper performance of the scrubber system is contingent upon good operating and maintenance procedures. Most scrubber malfunctions do not occur in the scrubber itself but in the interconnecting ductwork, dampers, fans, pumps, valves, and piping. A well-designed system will contain alarms to signal malfunctions such as excessive pressure drop, pump or blower faliure, and inadequate liquid level. Other parameters which should be monitored include recycle pump liquid rate, makeup water rate, slurry density and pH, and purge rate.

Pressure drop, ΔP, is an important scrubber system operating parameter. For packed beds and plate towers, pressure drop across the unit is not the operating parameter used to estimate removal efficiency, as it is for venturi scrubbers. However, pressure drop across the scrubber system is important in that it indicates whether gas flow is being restricted, which could degrade system performance. Abnormally high pressure drops can indicate clogging or unsteady-state operation, while low pressure drops may indicate channelling. If such conditions occur, waste feed should be shut off and the cause of the abnormal ΔP determined. Pressure drops for packed beds and tray towers are in the range of 2.0 to 7.2 inches of water. Venturi scrubbers used for gaseous and particulate control usually operate at a pressure drop of 20 to 50 in. W.G.

For control of HCl emissions, caustic soda and hydrated lime are usually added to the scrubber solution. Caustic soda is used in the form of an 18-20 weight percent caustic solution for scrubbing incinerator exhaust gases. Lime is made into a 10 to 32 weight percent $Ca(OH)_2$ slurry and used along with water as the scrubbing medium. Hot gases must be cooled, either by a venturi scrubber or a water quench section, before contacting caustic or lime solutions in a scrubber. A third option is to use water as the scrubbing medium, followed by neutralization of the scrubber water with caustic soda, lime slurry, limestone, or ammonia. The level of additives required depends on the chloride content of the waste stream incinerated. For single pass scrubbing, the chemical requirements are typically 60% in excess of the stoichiometric requirements. When scrubber liquid is recycled, the chemical requirements can be reduced to 5-30% in excess of the stoichiometric requirements.

The liquid-to-gas (L/G) ratio is an important design and operating parameter. It affects collection efficiency for both HCl and particulates. Typical L/G ratios for pollution control equipment which may be used in a system to incinerate PCBs are shown in Table 19. For packed beds and tray towers, a maximum L/G ratio is set by the flooding condition. Otherwise, the only limits on the amount of liquid used are practical, e.g., practical constraints of high pumping cost. Minimum values of L/G can be calculated based on stoichiometric neutralization of HCl by lime or caustic in the scrubber solution but will likely depend as much on practical considerations and operating experience.

In the design of gas absorption devices, the cross sectional area for gas-liquid contact is determined by the superficial gas velocity selected. The greater the gas velocity selected, the smaller will be the scrubber diameter but the larger will be the pressure drop and the cost of pumping the gas. The optimum gas velocity and diameter are sometimes determined by minimizing the annualized operating cost, including the fixed charges of the scrubber as well as the cost of power for operating. There are two additional factors that must be considered in the selection of gas velocity.

TABLE 19. TYPICAL L/G RATIOS

Device	L/G, $1/m^3$ (gal/1000 acf)	Reference
Quench chamber	0.1 to 0.5 (0.8 to 4)	128
Venturi	0.7 to 2.7 (5 to 20)	133
Packed bed or plate tower	0.8 to 10 (6 to 75)	133, 134
Spray tower	4 to 14 (30 to 105)	133

First, the gas velocity through the scrubber should allow sufficient residence time for gas-liquid contact. Second, in countercurrent tray or packed towers, the gas velocity should not exceed the flooding velocity. Operation at 60 to 70 percent of the flooding velocity is typical. Common gas velocities in tray towers, spray towers and packed beds range from 2.1 to 3.0 m/sec (7 to 10 ft/sec). In venturi scrubbers, gas velocities at the throat are significantly higher, typically in the 30 to 120 m/sec (100 to 400 ft/sec) range.

For absorption devices, higher efficiencies are attained by increasing the gas/liquid contact time. In tray towers, for example, greater depths of liquid on the trays lead to longer contact time and higher tray efficiency. Removal efficiencies for gaseous contaminants in packed beds are directly related to the depth of packing, which is proportional to the contact time. The contact time required for gas absorption is a function of mass transfer rate. The mass transfer rate, in general, is dependent upon four separate resistances: gas-phase resistance, liquid-phase resistance, chemical reaction resistance, and a solids dissolution resistance for scrubbing liquids containing solid reactants. For absorption of gases that are highly soluble or chemically reactive with the scrubbing liquid (such as the absorption of HCl by caustic solution) the contact time required for 99 percent removal is extremely short and of the order of 0.4 to 0.6 sec.

4.1.1.4.4 Ash handling and scrubber effluent disposal--Incineration does not eliminate all of the disposal problems associated with PCB wastes. Most incinerators produce waste streams which themselves must ultimately be disposed of. These wastes include ash or inert residues and liquid effluents from wet scrubbers used for HCl and/or particulate control. If systems are operated correctly, these effluents should be non-hazardous, and amenable to standard treatment methods. However, in some cases, these secondary waste streams may contain unburned PCBs or other hazardous substances and may require special handling.

A typical waste disposal scheme for incineration of PCBs is shown in Figure 22. Not all waste streams indicated in the figure are produced at all facilities.

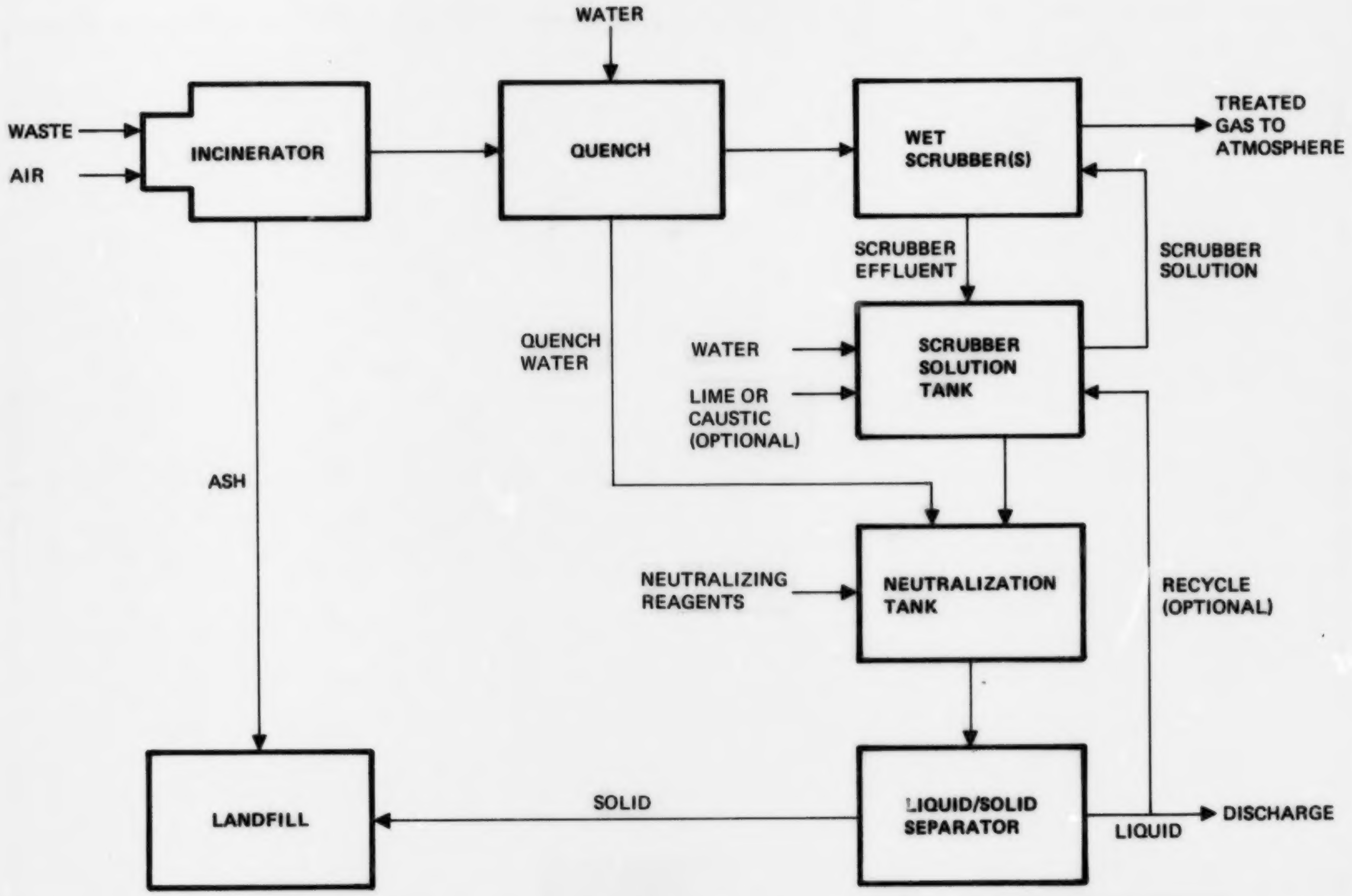

WATER
WASTE
AIR
INCINERATOR
QUENCH
WET SCRUBBER(S)
TREATED GAS TO ATMOSPHERE
SCRUBBER EFFLUENT
SCRUBBER SOLUTION
QUENCH WATER
WATER
LIME OR CAUSTIC (OPTIONAL)
SCRUBBER SOLUTION TANK
ASH
NEUTRALIZING REAGENTS
NEUTRALIZATION TANK
RECYCLE (OPTIONAL)
LANDFILL
SOLID
LIQUID/SOLID SEPARATOR
LIQUID
DISCHARGE

Figure 22. PCB incineration waste disposal.

For incineration of solid wastes, an ash stream is produced from the incinerator. This contains mainly non-combustible metal oxides, but it may contain small quantities of organic matter not destroyed by combustion, such as residual PCBs or PCDFs (see Section 2.5). The ash is sometimes slurried to minimize dust problems in handling. PCB concentrations in the ash greater than 50 ppm would require further disposal action as per the PCB Regulations.

Liquid effluents include quench water and spent scrubber liquor. These streams will contain dissolved HCl and dissolved solids from caustic or lime addition. Particulates scrubbed from the gas stream will also be present. These solutions are normally neutralized and subjected to some type of treatment (e.g., settling in ponds) for suspended solids removal. Clear liquid from the liquid/solid separation is either recycled or discharged, while settled solids are eventually landfilled. The gross parameters of concern in such a liquid discharge are pH and total dissolved solids (TDS). Some chlorinated organics and metals may be present at low levels from having been scrubbed from the gas stream. Discharge of these liquids after treatment is governed under the NPDES permit system.

An evaluation of the adequacy of waste disposal methods and equipment should consider the quantity and characteristics of wastes produced and the suitability of the design, construction, and operation of system components.

The quantity and character of ash produced depends on the waste burned and the incinerator type used. Ash quantities can be estimated from the ash content of the incinerator feed, allowing for some entrainment of fly ash in the combustion gas stream. The ash handling system (e.g., hoppers, conveyors) must be of sufficient capacity to handle all the ash produced. The materials of construction must be resistant to corrosive and abrasive ash slurries. A sampling/analysis plan should be implemented to ensure adequate chemical characterization of the ash.

The quantity of spent scrubber and quench water effluents which require disposal depends on the water use pattern at the facility. The use of recycle will greatly affect the quantity and chemical nature of these liquid effluents. For a single-pass scrubbing system, large amounts of wastewater are produced; the actual quantity is determined by the liquid-to-gas ratio used. The characteristics of single-pass scrubber effluents are highly variable and depend on waste feed rate and chlorine content, liquid feed rates, and scrubbing efficiency.

If scrubber water is recycled, total dissolved solids (TDS) build up in the scrubber solution which is recirculated until TDS reach about 3% (135), at which point a portion of the stream is removed (blowdown) and replaced with fresh solution. The quantity of blowdown is much less than the quantity of once-through effluent to be disposed of. The blowdown rate varies with waste chlorine content and liquid feed rate.

The overall water use pattern at a facility can employ either treatment and discharge or total containment of liquid effluents. Recycle can be incorporated into either scheme. The design of a system for treatment and discharge must ensure adequate removal of suspended solids. Laboratory test data on settling rate for solids in the effluent can be used with data on effluent flow rate and the volume of the settling ponds (and/or tanks) to determine whether adequate holdup time will be provided to remove suspended solids. A discharge permit will be required and will mandate certain effluent monitoring requirements. Total containment of liquid effluents in a lined evaporation pond may be feasible, especially in regions where the net evaporation rate is high. Recycle of pond water would likely be practiced at a facility using the total containment option.

Construction materials for scrubber water handling must be carefully chosen. Experience has shown that conventional materials (iron, carbon, steel, concrete) are susceptible to corrosive attack by scrubber solutions. Proper material selection, especially in areas of high flow velocity, is essential to avoid the necessity of frequent shutdowns for maintenance. Non-metallic coatings and corrosion-resistant metal alloys are recommended for equipment which will be in constant contact with scrubber wastewater. Ponds should be lined to prevent seepage since the chloride ion is quite mobile. Plastic or treated clay liners are preferred. Pond capacity will depend on influent (scrubber water, rainfall, runoff) rates, effluent (recycle, discharge, evaporation) rates, and safety factors. Evaporation rates will be substantially less for scrubber wastewater than for pure water because of the high concentration of dissolved salts.

4.1.1.4.5 Alternatives for HCl control--PCB incineration in cement kilns and commercial recovery of HCl represent two alternatives for HCl control. Recovery systems can produce commercial-grade hydrochloric acid (20-60% HCl) by utilizing aqueous solutions to absorb HCl (135). The resulting solution can be concentrated by water extraction procedures. Residual HCl in the combustion product gas stream can be removed by conventional wet scrubbers.

Cement kilns provide a desirable alternative for HCl control, as they represent a technology which can combine waste disposal with resource recovery (20,24). PCB liquids provide heat and chlorine needed for the production of cement clinker. Kiln temperatures and residence times are sufficient to destroy the PCBs, and HCl liberated from combustion is absorbed by the cement clinker. Solid PCB wastes should not be incinerated in cement kilns when the flow of solids is countercurrent to the gas flow, because PCBs volatilized from the incoming solids would escape in the exit gas without passing through the kiln. The chlorine input to the kiln should not exceed about 0.4% by weight of the clinker production rate (20). This limitation is based on the fact that when too much chlorine is fed to the kiln a "ring" of scale can build up inside the kiln, restricting solids flow, and forcing shutdown.

4.1.1.5 Process Control System Evaluation--

The most important aspect of a process design, from the standpoint of operating personnel, is the process control scheme. In evaluating process control schemes, several things should be considered in a general sense:

- Controls must deal with the unexpected, not just day-to-day trimming of operating parameters.
- Analysis of an operating problem in the field is much harder than analysis in the office.
- Control systems must be kept simple. They must be understandable to the average operator.

In order to achieve the required degree of process control, the operator must specify exactly what variables will be controlled, the desired values (set-points) for the controlled variables, what variables will be manipulated to achieve the desired set-points, and how such manipulation will be accomplished. To control properly a process facility, five parameters must usually be measured: 1) temperature, 2) pressure, 3) flow rate,

4) liquid level, and 5) composition. These parameters should be measured both for local display and for transmission to a remote control room. Since the measurement equipment must give an accurate representation of the parameter measured, the type and location of measurement equipment should be specified by the operator. Proper control hinges not only on accurate measurement of the controlled variables but also on selection of suitable equipment to regulate the manipulated variables.

All incinerators should be equipped with process controls to regulate waste and air flows (manipulated variables) to ensure maintenance of desired combustion conditions such as temperature and oxygen level (controlled variables). The incinerator must be equipped with automatic shutdown systems for waste flow which actuate during incinerator system malfunction. The type of controls needed are slightly different for liquid and non-liquid PCB incinerators. The two system types are discussed separately below. Some process control systems are mandated by the PCB Regulations and must be automatic. Others may be automatic or manual and, although not required, are necessary for safe incinerator operation.

4.1.1.5.1 Process controls for liquid PCB incinerators--PCB Regulations applicable to liquid PCB incinerators require that waste flow to the burners be cut off automatically whenever:

- Combustion temperature drops below the minimum allowable temperature for thermal destruction, or
- Excess oxygen falls below the required percentage, or
- Monitoring and recording devices for CO, CO_2, or O_2 malfunction, or
- Measuring and recording devices for PCB feed rate malfunction

Although not required by the regulations, the process control system should be designed to cut off waste flow in the event of:

- Loss of combustion air and/or auxiliary fuel flow, or
- Burner flameout, or
- Malfunction in the pollution control system (see Section 4.1.1.4).

The following guidelines apply to the type and location of measurement equipment used for process control:

- Temperature - Combustion temperature should be based on measurement of the gas stream or wall temperature at the combustion chamber outlet. Wall temperatures will be less than gas temperatures and can either be used as a conservative estimate of combustion temperature or can be correlated with gas temperature by prior calibration. Wall temperatures may be accurately measured with standard thermocouples. Gas temperatures cannot accurately be measured with standard shielded thermocouples. Because of thermal re-radiation shielded thermocouples will give low readings for temperature. Velocity thermocouples (suction pyrometers) should be used with such hot gases in preference to thermocouples, thereby avoiding re-radiation effects. Exit gas temperature less than 1100°C should automatically trigger waste flow shutdown. Excessive temperature, which may be indicative of insufficient combustion air, should also trigger shutdown. Cutoff temperature should exceed that associated with normal process variations but should be low enough to protect the system from severe thermal shocks.

- Oxygen level - Oxygen concentration should also be measured at the combustion chamber outlet because air leaking into the system could bias oxygen measurements taken downstream on the high side. Care should be taken in selection and installation of oxygen analyzers since their reliability is often poor (sample taps frequently plug). Exit gas oxygen concentrations less than 3% (wet basis) at combustion temperatures from 1100°C to 1500°C or less than 2% (wet basis) at combustion temperatures of 1500°C and above should automatically trigger waste flow shutdown*
- Flow rate - Flow rate should be measured and recorded for waste and fuel, combustion air, and scrubber solution. Failure of measurement equipment and/or loss of flow from pump failure should automatically trigger waste flow shutdown. Flow rates can be measured by means of an orifice plate, sonic-type flowmeter, or rotameter. (The latter is only applicable to local display.) Flow rates should be measured downstream of any pumps and in-line filters and upstream of the flow control valve. Liquid feed to the burner should be controlled to ensure the proper mix of fuel and waste. Normally, secondary air will be fed at a constant rate, while outlet temperature is controlled by adjustments in the waste or fuel feed rate within the operating range of the burner. To maintain air/fuel stoichiometry in the burner on turndown, the burner must be equipped with a primary air feed control system to pump or aspirate primary air to the burner in proportion to the fuel/waste feed rate.
- Pressure - Pressure drop across the pollution control system and across individual process units should be measured. The

---

* Wet basis is selected because operations should ensure at least 2% (or 3%) oxygen in the combustion chamber. Concentrations reported on a dry basis will be greater than those reported on a wet basis for the same stream.

implications of abnormal pressure drops are discussed in Section 4.1.1.4.

- Liquid level - Liquid levels in fuel, waste, and scrubber solution tanks should be monitored periodically to prevent overflow and to ensure adequate supplies of these fluids to the process. Gauge glasses or automatic sensors can be used.
- Flameout - Problems with the automatic temperature control system occur on loss of ignition, or flameout. When flameout occurs, the temperature in the incinerator drops, and more waste is automatically fed to the burner. Without a heat source for ignition, however, this waste passes through the incinerator partially or completely unburned. Thus, temperature continues to drop, more waste is automatically injected, and the problem of incomplete combustion is magnified. To prevent this phenomenon from occurring, burners should be equipped with flame scanners. These devices sense ultraviolet radiation from the flame. When used in conjunction with an automatic waste feed cutoff, flame scanners immediately terminate the feed to the burner on loss of ignition.

Flame scanners are usually designed to sense ultraviolet radiation from gas or fuel oil flames. Flame stability for these fuels is generally greater than for burning wastes, which are usually less homogeneous than fuels. For example, organic wastes containing a large amount of water burn with a relatively unstable flame, particularly when slugs of water pass through the burner. Although flameout may not occur, flame scanners often sense loss of ignition, resulting in unnecessary waste feed cutoff. To prevent this, flame scanners can be used in conjunction with temperature sensors at the combustion chamber outlet. With this system, feed is only stopped by a combination of flameout, as sensed by the flame scanner, and low temperature in the combustion chamber. This considerably reduces operating problems when relatively heterogeneous wastes are being burned. If the low temperature cutoff is set to the minimum temperature needed for waste destruction, release of products of incomplete combustion (PIC) to the environment is also prevented.

The equipment in the control system consists basically of monitors, pumps, and valves. Proper system design should take into account equipment type and redundancy. Guidelines are presented below:

- Monitors - Except when measuring flows, the sensing point for an alarm or automatic shutoff should not be shared with the sensing point used to indicate or record the parameter in the control room.

For critical services, separate sensing should be used for local indicators, control room recorders, alarms, and automatic shutoffs. Redundant flow sensors are not critical but may be advisable on the PCB feed stream to prevent shutdown should a single device fail.

- Pumps - Pump types were discussed in Section 4.1.1.2.1. Fuel and waste feed pumps and scrubber liquor pumps should be redundant to prevent shutdown in the event the primary pump fails.
- Valves - Emergency shutoff valves should be of the diaphragm, solenoid, or weight- or spring-operated fusible-element types. They should be rated for the expected flow rate, temperature, pressure, and fluid being handled. They should have the following performance capabilities: 1) close in the direction of liquid flow so that system pressure holds valve closed, 2) close on failure of operating electrical or air supply, 3) close against a pressure of at least 150% of design rating, and 4) close within 5 seconds of actuation.

4.1.1.5.2 Process controls for non-liquid PCB incinerators--PCB Regulations applicable to non-liquid PCB incinerators require that waste flow be cut off automatically whenever:

- Monitoring and recording devices for carbon monoxide, carbon dioxide, or oxygen malfunction, or
- Measuring and recording devices for PCB feed rate malfunction.

Although not required by the PCB Regulations, the process control system should be designed to cut off solid and liquid PCB waste flows to the primary combustion zone in the event that:

- Combustion temperatures at the afterburner outlet exceed allowable limits based on thermal destruction efficiency (low temperature limit) and the thermal limits of the system (high temperature limit), or
- Excess oxygen at the afterburner outlet falls below the level required to ensure adequate PCB destruction, or
- Flameout occurs in the afterburner,* or
- Loss of combustion air and/or auxiliary fuel flow occurs in the afterburner or primary combustion zone, or
- Flameout of gas or liquid burner(s) occurs in the primary combustion zone, or
- Combustion temperatures at the outlet to the primary combustion zone are too low to produce complete vaporization of PCBs, or

---

* This is an extremely undesirable situation. Therefore, only conventional fuels or "clean" homogeneous wastes should be fired in the afterburner.

- Subatmospheric pressure is lost at the outlet of the primary combustion zone.

The guidelines for liquid PCB incinerators set forth in Section 4.1.1.5.1 should be applied to evaluation of the adequacy of the afterburner control system.

4.1.1.5.3 Alternative process control schemes--Some or all of the process control requirements of the PCB Regulations may be waived if the operator submits contingency plans indicating what alternative measures would be taken in lieu of the required automatic shutdowns. Such contingency plans would have to be approved by the RA.

4.1.2 Operational Data Capability

This document has drawn a distinction between operational data and monitoring data. Operational data include process:

- Temperatures
- Flow rates (e.g., waste, auxiliary fuel, combustion air, and scrubber water)
- Pressures

Monitoring data include:

- O_2, CO_2, and CO concentrations
- PCBs, organochlorines, and total particulate in the stack gas
- PCBs in scrubber water and solid residues.

Guidelines were given in Section 4.1.1.5 for evaluating incinerator process control systems. Typically, instruments used to control process parameters provide signals for readout and/or recording of operational data. In evaluating the Initial Report, the RA should determine whether the temperature and flow control instrumentation provide for recording, at a minimum, the parameters required by the PCB Regulations: 1) combustion zone temperature and 2) rate and quantity of PCBs fed to the incinerator.

Monitoring data, as defined above, are treated in Section 4.1.3.

4.1.3 Effluent Monitoring Capability

An Annex I incinerator will produce three generic process effluent streams:

- Stack gas
- Scrubber effluent
- Solid residues (from non-liquid PCBs)

In evaluating the Initial Report, the Regional Administrator must evaluate the facility operator's description of instrumentation, sampling equipment, and analysis methods for the measurement and determination of:

- CO, CO_2. O_2, NO_x, PCBs, organochlorines, HCl and total particulate matter in the stack gas
- PCBs in the scrubber effluent
- PCBs in the solid residues

This section describes means of evaluating the methods for measurement and determination of these parameters.

The PCB Regulations do not establish special requirements for monitoring during a Trial Burn. The choice of minimum monitoring requirements for a Trial Burn is, therefore, between:

- The routine operation requirements of 761.40(a)(7) and (9), or
- The more extensive requirements of 761.40(a)(6)(i), (ii), and (iii) for, respectively, first disposal use or after modification.

For a Trial Burn, it is recommended that the more extensive monitoring requirements be imposed, so that more extensive operational data can be acquired. Consequently, it is recommended that the Initial Report reflect and be evaluated upon the more extensive monitoring requirements.

The effluent monitoring capability of a facility is determined by the facility operator's description of the appropriate streams to be sampled and the means of sampling them, as described in subsequent sections.

4.1.3.1 Gaseous Effluent Monitoring Capability--

The gaseous effluent stream of most concern is the stack gas. The facility is required to monitor CO and O_2 continuously and CO_2 periodically as required by the Regional Administrator. Presumably, NO_x must be monitored periodically although this is not stated. Preferred instruments for CO and O_2 monitoring are described in Section 2.4. A non-dispersive infrared monitor may be used for CO_2 although other types of devices can be used because the measurement need not be continuous. CO_2 measurement is also necessary for stack gas molecular weight determination, and an instrument such as an ORSAT analyzer is acceptable. EPA Method 7 (40 CFR 60) is the reference method for NO_x analysis. However, there are several manufacturers of instruments that measure NO_x by chemiluminescence, and these are accepted as equivalent to Method 7 for ambient air monitoring.

Measurement and determination of PCBs, organochlorines, HCl and total particulate matter are performed using sampling trains. The recommended trains are described in Section 2.3.1.1, and details are given in Reference 60.

Other gaseous effluent streams are fugitive ones, typically from waste handling operations. For example, PCB emissions can result from shredding PCB capacitors unless the shredding operation has a suitable vapor control system.

Combustion gas measurements are typically performed near the exit plane of the stack, as discussed in Section 4.1.4.1.

4.1.3.2 Liquid Effluent Sampling Capability--

The PCB Regulations require monitoring of the scrubber effluent stream (761.40(a)(9)). In addition, the Initial Report should describe monitoring during a Trial Burn of all other liquid process input and output streams so that their (potential) contribution of PCBs to the scrubber effluent can be determined.

Prior to sampling any liquid stream, plant data concerning the stream must be available. Many streams exist under pressure or elevated temperature or both; attempts to sample such a stream without prior knowledge of its condition could result in severe injury. The following data points must be available: temperature, pressure, flow rate, stream identification (e.g., blowdown, cooling tower, etc.), and solids content.

Tap sampling is generally applicable to contained liquids in motion or static liquids in tanks or drums. Slurries are occasionally sampled using this technique, but sample representativeness is unreliable if solids content exceeds 10%. If sampling valves or stopcocks are not available, samples may be taken from water-level or gauge-glass drain lines or petcocks. Parameters which must be considered in determining the adequacy of liquid sampling capability are: 1) the location of the tap (is it in a depression in the pipe, at the top, middle or bottom of a tank or pipe, etc.), 2) how far into the pipe it extends (wall effects), 3) the ratio of the diameter of the tap to the diameter of the pipe (the tap diameter must be large enough to sample a significant volume percent of the effluent), and 4) the flow rate of the effluent out of the tap should not exceed 500 ml/min.

Automated samplers are commercially available which can sample almost any process stream in any of several programmed modes. Use of such samplers, while not required, increases the likelihood that a representative sample will be obtained. Table 20 gives a partial list of sampling equipment which can be used to monitor liquid streams. When available, the use of an automated composite sampler is preferred to manual tap sampling.

4.1.3.3. Solid Effluent Sampling Capability--

There are no specific requirements for monitoring solid residues from an Annex I incinerator. However, if this residue is to be disposed of properly, it is necessary to know its PCB content. Similarly, for non-liquid PCBs, it is necessary to monitor the solids fed to the incinerator in conjunction with the requirement for determining PCB feed rate.

Solids are typically sampled by grab techniques. Streams are sampled at an established frequency, and the individual grab samples from a given stream are typically added together to form a composite sample. The frequency of grab sampling depends on an assessment of the variability of the solid stream. For example, if PCB capacitors of varying PCB content are being shredded before entering the incinerator, the shredded material should be sampled at fairly short intervals (e.g., 15 minutes) so that a representative composite sample can be formed. Because such a composite sample can be quite large, it is typical to mix it thoroughly and then to take a smaller sample of the composite for subsequent analysis. A technique used for sampling a composite is coning and quartering and is given in detail by ASTM D 346-78 (52). Additional information is given in Reference 53.

It is preferable to sample a moving stream rather than a stationary storage pile. This is particularly true if a large solids size distribution exists because settling occurs which causes size segregation. Thus, if solid influent or effluent streams are handled by moving belts, sampling

TABLE 20. PARTIAL LIST OF LIQUID SAMPLERS

Manufacturer	Model	Mode of Operation		Mounted In-line	Sample Port Needed
		Continuous	Programmed		
Fluid Kinetics Inc.	C50-142	X	X		X
Quality Control Equipment Co.	CVE	X			X
Sigmamotor	6100	X	X	X	
Collins	42		X	X	
Isolok	M4		X	X	
Horizon Ecology Co.	7578-7579		X		X
N-Con	Sentry 505		X		X
Manning	S-5000	X	X		X

should be from the belt, if possible, rather than a stationary pile. When belt sampling is possible, full cross-stream cuts should be taken for compositing. Again, frequency depends on an assessment of the variability of the stream being sampled.

4.1.4 Sampling Locations

A detailed drawing of the facility should be provided with the Initial Report which clearly indicates the sampling locations available. A sample must be taken on the exit side of the last combustion gas treatment step to determine the composition of the stack gas. If a Trial Burn is subsequently required by the Regional Administrator, all input and output streams must be sampled or monitored. This includes the fuel, waste, cooling water (if present), scrubber makeup water, etc., entering the unit; and incinerator bottom ash, scrubber effluent, and stack gases produced during the incineration of PCBs. In determining the adequacy of test port locations, it is therefore necessary to examine whether a representative sample can be obtained from each influent and effluent stream, whether gaseous, liquid, or solid.

4.1.4.1 Stack Sampling Locations--

Organic compounds tend, to a greater or lesser extent, to be adsorbed on particulate matter. Consequently, the stack sampling effort must include a representative sample of particulate matter. The particulate matter must be analyzed for PCBs, and this result must be part of the overall PCB emission value. The adsorption equilibrium position (or extent of adsorptions) is highly temperature dependent. Therefore, the extent of PCB-particulate matter adsorption will vary with temperature and thus position in an incinerator system. Consequently, it is meaningless to distinguish between PCBs in the vapor and adsorbed phases. The total emissions value - not the distribution - should be reported.

Careful selection of a stack sampling port is required so that a representative sample of particulate matter can be obtained. The selection criteria of EPA Method 1 are intended to help the sampler select a port in a region of the stack where gas flow is not turbulent. Sampling must be within ± 10% of isokinetic (i.e., the linear velocity of gas entering the probe nozzle must be within ± 10% of the linear velocity of the gas in the stack).

A sampling port should be available which is at least 8 stack or duct diameters downstream and 2 diameters upstream from any flow disturbance such as a bend, expansion, contraction, or visible flame. If a port meeting these requirements is impractical, an alternate site that is at least 2 stack or duct diameters downstream and 0.5 diameter upstream from the flow disturbances is acceptable. For a rectangular cross section stack, an equivalent diameter calculated from the equation given in EPA Method 1 (40 CFR 60) should be used. When the 8 and 2 diameter criterion can be met, the minimum number of traverse points should be 12 for stack diameters greater than 0.6 m (24 in.) and 8 for stack diameters equal to or less than 0.6 m (24 in.). When the 8 and 2 diameter criterion cannot be met, EPA Method 1 should be consulted. In addition, for stacks greater than 0.6 m (24 in.) in diameter, no sampling points should be selected within 2.54 cm (1 in.) of the stack walls; and for stacks equal to or less than 0.6 m (24 in.) in diameter, sampling points should be selected within 1.27 cm (1/2 in.) of the stack walls. Method 1 is not applicable to stacks containing cyclonic or swirling flow or stacks smaller than about 0.3 m (1 ft.) in diameter or 0.07 m^2 (0.8 ft^2) in cross sectional area.

4.1.4.2 Liquid Sampling Locations--

Process liquid streams must be sampled during the Trial Burn. Thus, the Initial Report should describe locations for sampling appropriate liquid streams:

- Liquid PCB feed
- Auxiliary fuel feed
- Inlet scrubber water
- Outlet scrubber water
- Caustic or lime feed, if not combined with feed water prior to entering the scrubber
- Other pertinent streams

Samples should be taken at points which provide samples as representative as possible. A flowing stream containing particulate material or insoluble or immiscible phases will, in general, be stratified. In general, then, an optimum sampling point will be located after a bend, which promotes turbulence and, hence, attainment of homogeniety.

4.1.4.3 Solid Sampling Locations--

Process solid streams must be sampled during the Trial Burn, if it is required by the Regional Administrator. Thus, the Initial Report should describe those stream(s) and sampling point(s). Appropriate streams are:

- Non-liquid PCB feed
- Solid residue
- Lime or caustic for scrubber.

Some units may have automatic composite samplers, and these should be used in preference to manual methods.

4.1.5 Waste Characterization and Feed Rate

In addition to the amount of PCB material to be burned, the Initial Report should describe the method by which the feed rate will be determined. A specific description of the type of waste to be incinerated must be provided, and the PCB content of the waste must be stated. In most cases, this analysis will have been performed on the waste prior to the planned destruction. Test procedures for PCBs are discussed in Section 2.3.2 and Section XII of the Preamble to the PCB Regulations. Since the PCB wastes are toxic, manual sampling of the waste feed should be performed carefully. The Regional Administrator may choose to accept the prior analysis of the PCB waste in place of sampling the actual waste feed. This, however, places the incinerator operator at a disadvantage by not knowing the exact composition of the waste as it enters the incinerator.

The feed rate of the fuel and waste as well as the total feed rate must be measured at least once every fifteen minutes. Measurement of such flows can be accomplished in a variety of ways, and the accuracy of the measurement should be the main criterion for acceptance. A wide variety of techniques and instruments are employed for process stream flow measurement. Table 21 is a partial list of flow monitors and manufacturers based on four different principles, each of which applies to certain liquid streams. The feed rate of non-liquid PCBs, PCB articles, PCB equipment, or PCB containers may be more difficult to determine accurately, and the method by which these data will be acquired should be detailed.

TABLE 21. PARTIAL LIST OF FLOW RATE MEASUREMENT INSTRUMENTS

Manufacturer	Model	Range	Contact	Principle
Advanced Instrumentation	Subsize	150-900 gpm	Direct	Flume
Columbia Controls	120,T30,B40	0-50 ft/sec	None	Doppler Shift
Hoffer Flow Controls, Inc.	Various	0.50-12,000 gpm	Direct	Turbine
Manning	580	0.15-100 ft/sec	None	Ultrasonic
Fisher and Porter	10LV2000	0-44 gpm	Direct	Vortex Shredding

4.1.6 Storage Capability

PCB Regulations prescribe time limits and facility requirements for storage of PCB Items prior to their eventual disposal. The storage for disposal regulations, 40 CFR 761.42, comprise Annex III of 40 CFR 761 Subpart E.

4.1.6.1 Time Limits--

Three time limits apply to storage of PCB Articles and PCB Containers:

- Any PCB Article or PCB Container stored for disposal before January 1, 1983 must be removed from storage and disposed of before January 1, 1984.
- Any PCB Article on PCB Container stored for disposal after January 1, 1983 must be removed from storage and disposed of within one year from the date it was first put into storage.
- Certain PCB Items may be stored temporarily for up to thirty days from the date they are removed from service, in areas which do not meet the normal storage facility requirements.

To ensure adherence to these time limits, PCB Articles and PCB Containers must be dated when they are placed in storage. Marking and recordkeeping requirements are prescribed by the PCB Regulations in Subpart C § 761.42(b)(10) and Annex VI § 761.45, respectively.

4.1.6.2 Facility Requirements--

Facilities for the storage of PCBs and PCB Items designated for disposal must, at a minimum, meet the following criteria (40 CFR 761.42(b)(1)):

- Adequate roof and walls to prevent rain water from reaching the stored PCBs and PCB Items
- An adequate floor which has continuous curbing with a minimum six inch high curb. The floor and curbing must provide a containment volume equal to at least two times the internal volume of the largest PCB Article or PCB Container stored therein or 25 percent of the total internal volume of all PCB Articles or PCB Containers stored therein, whichever is greater
- No drain valves, floor drains, expansion joints, sewer lines, or other openings that would permit liquids to flow from the curbed area
- Floors and curbing constructed of continuous smooth and impervious materials, such as Portland cement concrete or steel, to prevent or minimize penetration of PCBs
- Not located at a site that is below the 100-year flood water elevation

In addition to the § 761.42(b)(1) criteria, the following guidelines should be considered in evaluating the storage facilities:

- Storage capacity should be adequate to accept all incoming waste shipments and should slightly exceed the maximum desired inventory.
- Incompatible corrosive or reactive wastes should be segregated in the storage area.
- Materials used in construction of storage tanks for PCBs should be compatible with the physical and chemical form of the waste contained.
- PCBs should not be stored in an unwashed tank which previously contained incompatible materials.
- If underground storage tanks are used, provisions for gaging, pumping, and leak detection should be such as to minimize the possibility of a PCB release. Above-ground storage is preferred.
- Provisions for drainage of diked areas should assure that uncontrolled discharge to storm drains or surface waters does not occur. This may necessitate pumping stormwater drainage to an on-site pond or treatment system and pumping spilled wastes to alternate storage tanks.

- Spill cleanup equipment and supplies should be available to contain spills.
- Personnel safety equipment and procedures should be used as needed.

Temporary storage in an area that does not meet the § 761.42(b)(1) criteria is allowed for up to thirty days in some cases, provided the date of removal from service is attached to the PCB Item or PCB Container. These cases are:

- Non-leaking PCB Articles and PCB Equipment
- Leaking PCB Articles and PCB Equipment if the PCB Items are placed in a non-leaking PCB Container that contains sufficient sorbent materials to absorb any liquid PCBs remaining in the PCB Items
- PCB Containers containing non-liquid PCBs such as contaminated soil, rags, and debris
- PCB Containers containing liquid PCBs at a concentration between 50 and 500 ppm, provided a Spill Prevention, Control and Countermeasure Plan has been prepared for the temporary storage area in accordance with 40 CFR 112. In addition, each container must bear a notation that indicates that the liquids in the drum do not exceed 500 ppm PCB.

Non-leaking and structurally undamaged PCB Large High Voltage Capacitors and PCB-Contaminated Transformers that have not been drained of free-flowing dielectric fluid may be stored outside a facility which meets the § 761.42 (b)(1) criteria until January 1, 1983. To allow for leaks, such outside storage is permitted only when storage space inside the facility is immediately available to handle at least 10 percent of the capacitors and transformers temporarily stored outside. Weekly checks for leaking capacitors and transformers must be performed. Storage of drained PCB-Contaminated Transformers is not regulated under the current PCB Regulations.

No item of movable equipment used for handling PCBs and PCB Items in the storage facilities and that comes in direct contact with PCBs can be removed from the storage facility area unless it has been decontaminated as specified in Annex IV, § 761.43.

All PCB Articles and PCB Containers in storage must be checked for leaks at least once every 30 days. Leaking PCB Articles and PCB Containers and their contents must be transferred immediately to properly marked non-leaking containers. Spilled or leaked materials must be immediately cleaned up, using sorbents or other adequate means and the PCB-contaminated materials and residues disposed of in accordance with § 761.10(a)(4).

Storage containers for liquid PCBs must comply with the Shipping Container Specifications of the Department of Transportation (DOT)* or be designed and constructed so as to provide the same degree of strength, durability, and leak prevention. Bulk storage of liquid PCBs is allowed, provided: 1) tanks are designed, constructed and operated in compliance with Occupational Safety and Health Administration Standards, 29 CFR 1910.106, for Flammable and Combustible Liquids, and 2) a Spill Prevention, Control and Countermeasures (SPCC) Plan in accordance with 40 CFR 112 is implemented.

Final and interim final RCRA hazardous waste regulations (45 FR 33153) for owners and operators of hazardous waste disposal facilities potentially overlap the PCB Regulations, which will be incorporated into Phase II RCRA regulations. Therefore, PCB disposal facilities will eventually have to meet all the requirements of RCRA, in addition to the current PCB Regulations.

4.1.7 Site Specific Concerns

This Section addresses several site-specific concerns that the Regional Administrator should consider when evaluating an Initial Report. These site-specific concerns are not technical requirements of the PCB Regulations, however, they merit consideration during the evaluation process.

4.1.7.1 Safety Assessment--

PCBs have been found repeatedly to be widespread in analyses of human tissues. For example, detectable levels of PCBs have been reported in adipose tissue samples of up to 91 percent of individuals sampled in a survey of the United States population (136). This finding suggests that environmental contamination may be a significant source of human exposure. Likely routes of exposure for the general population are water and particularly food, while inhalation and dermal contact are likely to be more significant routes in occupational exposure.

---

* See PCB Regulations, 40 CFR 761.42(c)(6) for reference to applicable DOT codes.

This section discusses worker safety and exposure potential from PCB emissions from Annex I incinerators and high efficiency boilers.

4.1.7.1.1 Worker safety--Exposure to PCBs may occur during their transport, storage, and disposal. If the American National Standards Institute (ANSI) guidelines are followed, work exposure should be nil, inasmuch as the recommended procedures entail use of closed systems for the manufacture, transport, and handling of PCBs. Nevertheless, even when these guidelines are followed, workers may still be exposed to PCBs as a consequence of equipment malfunction or breakdown, leaks, spills, and various accidents.

There are three routes by which a toxic agent can enter the body: ingestion, inhalation, and skin absorption.

Ingestion or swallowing of industrial products is sometimes encountered when workers eat or even smoke without washing or when foods or cigarettes are stored near where the toxic materials are used. The potential of exposure to PCBs by this route in an Annex I incinerator or high efficiency boiler facility is, however, not very likely if proper worker indoctrination is performed. Skin absorption is a more insidious or hazardous route of entry into the body than ingestion because it is not easily noticeable. It generally occurs during transfer and handling of products or chemicals. Inhalation is a more general hazard than even ingestion or skin absorption because no visible physical contact between the worker and the compound is required. Airborne particulates, gases, and vapors not only contaminate the work space but, due to transportation by air currents, also contaminate the surrounding communities.

A study of occupational exposure in Japan found PCB vapors at levels between 13 and 540 $\mu g/m^3$ and airborne particulates between 4 and 650 $\mu g/m^3$ in a survey of six industrial plants. An additional finding of 6,270 $\mu g/m^3$ PCB particulates was associated with a spill. Blood PCB levels of 99 exposed workers averaged 370 ppb as compared to levels in 32 controls of 20 ppb. In Australia Aroclor 1242 levels between 2.22 and 0.32 mg/m^3 were observed in different areas of an electrical equipment manufacturing facility.

Workers in a capacitor impregnation room where inhalation was a major mode of exposure had higher levels of PCBs than did workers in another area where exposure was primarily dermal. A series of 30 control individuals were not found to have detectable PCB levels. The limit of detection in this study was not reported; however, in 1972, American control population blood levels of 0.3 to 3 ppb were reported (137).

It is difficult to differentiate between industrial exposure by inhalation and dermal absorption. Animal studies do indicate that animals exposed to PCB aerosols show rapid increases in liver PCB levels. Exposure to aerosol Pydranl A 200 for 15 minutes was reported to have resulted in the accumulation in the liver of 50 percent of the PCBs accumulated after two hours (131). The lung appears to be a good site of absorption, and certain occupational environments contain significant levels of airborne PCBs. The National Institute of Occupational Safety and Health has recently proposed an occupational exposure limit of 1.0 $\mu g/m^3$ on a time weighted average 10-hour day, 40-hour week basis (Natl. Inst. Occup. Safety Health, 1977). Assuming a tidal air volume of 10 m^3 in an eight-hour day and 100 percent absorption, the resulting dose at this exposure level would be 10 μg/day. At present, the OSHA Administrator's occupational exposure limit is 1 mg/m^3.

4.1.7.1.2 Exposure potential--The general populace is exposed when PCBs enter the ambient environment from the working environment. This can occur when recommended procedures are not followed, when leaks and spills are not contained and cleaned up, and when PCBs and PCB-contaminated items are not disposed of properly.

Prior to the restriction of PCB use, substantial losses to the atmosphere resulted from evaporation of plasticizers and from improper incineration (137). In 1972 terrestrial input from aerial fallout was estimated to be 915 to 1835 metric tons/year. Annual emission rates were estimated at 1375 to 2290 metric tons. In 1972 a study of PCB content in air in surburban areas in Florida and Colorado indicated that average atmospheric levels were approximately 100 ng/m^3 (137). Rates of fallout along the southern California coast were estimated to average 1800 kg/year over a 50,000 km^2 area (137). The distribution of PCBs is more highly concentrated in urban areas. The aerial fallout survey in southern California indicated that sectors in the urban areas around Los Angeles had fallout rates of up to 180 kg/yr while less industrialized sectors had rates as low as 30 kg/yr. A study of PCB levels in soil samples showed that they were rarely detectable in agricultural soils but were found in 63 percent of urban samples from 19 cities. General human exposure to inhaled PCBs probably varies with the local conditions. Relative to the 9 μg/day intake estimated from the diet (131) non-occupational exposures by inhalation are probably small:

The evaluator of the Initial Report should:

- Evaluate the facility operator's description of worker safety plans.
- Evaluate the facility description in terms of operations that could cause unnecessary worker exposure to PCBs during operation.

4.1.7.2 Spill Prevention and Control--

EPA has published a manual which discusses both spill control and spill prevention (138). This report includes sections regarding: notification procedures; an inventory of information sources; methods for spill identification, assessment, and prevention; a guide for determining the best method of handling a spill; and suggested treatment techniques for numerous designated hazardous materials/chemicals, including PCBs. This manual is updated periodically to insure the contents are current. EPRI has recently published a three-volume handbook on PCBs: the first (8) discusses disposal technology; the second (121) discusses procedures for developing spill prevention and control plans; and the third (122) gives an example plan.

As was noted in Chapter 1, disposal facility operators are required to have a site-specific spill prevention and control plan that is in accordance with the National Plan (40 CFR 1510). Thus, the evaluator of the Initial Report should:

- Evaluate the degree of conformance of the facility operator's SPCC with the National and any State of local SPCCs.

4.1.7.3 Ambient Monitoring--

An Annex I incineration facility operating in accordance with the PCB Regulations will emit levels of PCBs that: 1) will have negligible environmental effects and 2) will be at the threshold of sampling and analysis methodology. Consequently, the PCB Regulations do not require monitoring of ambient air for

PCBs in the vicinity of an incineration facility during operations.

There is a reasonably high level of public concern about PCBs, and in some areas this concern is quite high. Recently, GCA Corporation has summarized (46) the adverse public reaction to the proposed PCB Trial Burn in a power boiler at the General Motors Bay City, Michigan, facility. Public opposition had significantly delayed accomplishing this Trial Burn. GCA cited a number of positive actions that could have been but weren't initially taken to allay public opposition.

Given the existence of public concern and potential opposition to incineration of PCBs, one positive action that could be taken is ambient monitoring for PCBs during a Trial Burn. Several high colume samplers of the type described in Section 2.3.1.2 should be placed around the facility to measure airborne PCB emissions.

The evaluator of the Initial Report should:

- Give consideration to potential public opposition
- Determine whether or not to require ambient air monitoring

4.1.7.4 Environmental Assessment--

The PCB Regulations do not require assessment of the potential environmental impacts of PCB destruction by Annex I incinerators or high efficiency boilers. It is clear from the Preamble that EPA considers that PCB emissions from Annex I incinerators and high efficiency boilers (44 FR 31519) approved in accordance with the PCB Regulations will not pose an unreasonable risk of injury to health or the environment. However, given the level of public concern over PCBs, it is recommended that EPA give consideration to preparing a general environmental assessment that will cover several "typical" commercial incinerator-site cases, particularly a case in which an incinerator is sited in a heavily populated or industrialized area. If monitoring in support of such an environmental assessment is deemed necessary, it could be performed at a Federal facility which will destroy only site-generated waste PCBs.

An environmental assessment includes the identification of sources of PCB loss to the affected environment; air pollution and water pollution modeling; description of sampling and analysis methods for testing; and descriptions of air, water, and solid waste pollution control technologies. Some general information pertaining to these sections is given in Appendix B. This information can be used as a guide to evaluate the type of information that should be included in environmental assessments of PCB disposal operations.

Air pollution modeling by plume dispersion techniques attempts to determing the PCB input to the surrounding community, principally from the stack. It uses a model to predict the location of the plume and the PCB concentration therein as a function of distance from the stack. The model commonly used is a Guassian plume and is more fully described in Appendix B. Wind direction, wind speed, and atmospheric stability are the primary variables in predicting the maximum ground level concentrations of a stack effluent. Plume dispersion modeling can also be used to predict dispersion of fugitive emissions.

If, after evaluating the Initial Report, the Regional Administrator determines that a Trial Burn is necessary, the Regional Administrator should consider whether local public concern warrants requesting that the facility operator perform air pollution modeling.

4.2 EVALUATION OF TRIAL BURN PLAN

This section presents a discussion of and guidelines for evaluating a Trial Burn plan, if a Regional Administrator has determined that a Trial Burn is necessary. Table 22 is a checklist of information required in the Trial Burn plan. Table 23 is a suggested Trial Burn plan outline used by EPA Region VI (139). Each of these items is discussed and means of evaluation addressed in subsequent sections.

The PCB Regulations do not specify the total amount of testing to be performed. On the basis of past Trial Burns and engineering judgement, it is recommended that the following test strategy be utilized:

- One background test while burning normal wastes and/or auxiliary fuel. Monitor for CO, O_2, CO_2, and NO_x. Sample for PCBs, RCl, HCl, TPM. Collect all pertinent liquid and solid samples for PCB and RCL analyses.

TABLE 22. CHECKLIST FOR EVALUATING A TRIAL BURN PLAN

1. Date of proposed Trial Burn
2. Quantities and types to be burned
    a. PCBs
        1. Quantities -
        2. Types -
        3. Concentration -
        4. Target feed rate: Waste______ PCBs______
    b. PCB Items
        1. Quantities
        2. Types
        3. Concentrations
        4. Target feed rate: Items______ PCBs______
3. Monitoring

Parameter	Interval	Location
O_2		
CO_2		
CO		
NO_x		
HCl		
RCL		
PCB		
TPM		
Rate PCBs		
Quantity PCBs		
Temperatures		

4. Sampling, analysis
    a. Types -
    b. Methods -
    c. Frequencies -
    d. Schedules -
5. Review of Results
    a. Name of reviewer -
    b. Address, telephone
    c. Qualifications
    d. Schedule

TABLE 23. SUGGESTED PCB TRIAL BURN PLAN OUTLINE (139)

- I. INTRODUCTION
  - A. Purpose of trial burn
  - B. References listed
  - C. Proposed dates of trial burn

- II. TRIAL BURN PROCEDURES
  - A. Quantity and type of material to be incinerated
  - B. Concentration of PCBs expected in feed streams
  - C. Operating conditions of incinerator (temp., dwell time, flow rates, etc.)
  - D. Expected O_2 and CO concentrations
  - E. Scrubber efficiency for HCl removal and total particulate emissions

- III. STACK PARAMETERS TO BE MEASURED (Method)
  - A. PCBs (EPA Method) PCB train with Florisil & XAD-2 resins
  - B. Chlorinated organics (Region 6 method) Tenax tubes
  - C. Particulates (Method 5)
  - D. HCl (NaOH impingers) (Included with particulate train)
  - E. NO_x (Method 7) (12 separate samples)
  - F. CO, O_2, and CO_2 (Method 3) (For molecular weight determination)

- IV. OTHER STREAMS TO BE SAMPLED
  - A. Feed rates for PCBs (Liquids and/or solids)
  - B. Scrubber influent and effluent
  - C. Incinerator ash (For PCB solids)
  - D. CO_2 measurement of stack gas for combustion efficiency calculation
  - E. List any deviations from above methods

- V. SAMPLING LOCATIONS (Including drawings)
  - A. Stack sampling location
  - B. Feed location
  - C. Scrubber and ash location

- VI. SAMPLE RECOVERY AND ANALYSIS
  - A. PCBs (stack, feed, scrubber, and ash)
  - B. Chlorinated organics
  - C. Particulates
  - D. HCl
  - E. NO_x

- VII. QUALITY ASSURANCE PROCEDURES
  - A. Spikes for extraction efficiencies
  - B. Blanks
  - C. Split Samples
  - D. Calibration Standards

- VIII. CHAIN OF CUSTODY PROCEDURES
  - A. Describe procedures
  - B. Provide example of chain of custody forms

- IX. SAMPLING SCHEDULE

- X. ANALYSIS SCHEDULE

- XI. DESCRIPTION OF CONTINUOUS MONITORS
  - A. Calibration Error test (0, 50%, and 90%)
  - B. Calibration Drift (2 hr.)
  - C. Calibration Drift (24 hr.)
  - D. Zero Drift (2 hr.)
  - E. Zero Drift (24 hr.)
  - F. Response Time
  - G. Accuracy Test for O_2 Monitor

- XII. QUALIFICATIONS OF SAMPLING AND ANALYSIS PERSONNEL (Resumes)

- Three tests while burning PCBs, PCB-Items, normal waste, and/or auxiliary fuel. Monitor, sample, and analyze as above.

A background test is necessary for the interpretation of test results when PCBs are incinerated. It is possible that normal waste or other process influent streams will contain PCBs, and if the normal waste contains organochlorines, it may produce RCLs upon incineration.

The recommended protocol is representative of past Trial Burn practices and is the minimum necessary for any statistical treatment of emissions data. A single test or two tests give, respectively, either no or minimum (range of values only) information on the reproducibility of PCB destruction.

4.2.1.1 Minimum Data Requirements--

The operational data which must be collected during a Trial Burn are more extensive than would be required for operation of the incinerator during routine PCB destruction, so that the Regional Administrator can accurately assess the capability of the incinerator to destroy PCBs adequately. All operator log sheets must be supplied for both the incinerator and the water scrubber and/or other applicable control device(s). As indicated in Table 22, these data must include at a minimum:

- Data from which to determine the residence time of the PCBs in the incinerator
- The flow rates of PCB waste, fuel, and total flow rate, at no longer than 15 minute intervals
- The temperature of the incinerator continuously measured and recorded
- Continuous monitoring of CO and O_2 and periodic monitoring for CO_2, NOx, HCl, PCBs, total organochlorines, and total particulate matter
- Any other requirements which may be prescribed by the Regional Administrator

Section 761.40 clearly intends that analysis is subsumed under the monitoring requirements. Therefore, the Trial Burn plan must describe analytical as well as monitoring methodology.

4.2.1.2 Adequacy of Equipment and Methodology--

In order that PCBs be completely destroyed in the incineration process, the flow of PCBs into the incinerator must be terminated when a change in operating conditions reduces thermal efficiency. The combustion temperature is determined via a thermocouple inside the incinerator or, as is ususal, attached to the inside wall. When the temperature drops below a preset value (minimum 1200 ± 100°C or 1600 ± 100°C, depending on oxygen content and residence time as per Section 761.40(a)(1) of the PCB Regulations), the flow of PCBs must be terminated. Similarly, a decrease in boiler oxygen to below 2 or 3% (depending on temperature and residence time as per Section 761.40(a)(1)) must cause the input of PCBs to stop. Failure of the monitoring equipment for oxygen, temperature, or feed rate of fuel or PCBs is also grounds for terminating PCB input to the incinerator. The equipment used for such monitoring must, therefore, demonstrate not only their accuracy and reliability, but must also have the automatic cutoffs required to interrupt PCB feed.

A partial list of suitable instrumentation for CO, CO_2, O_2, and NO_x was described in Section 2.4 and Table 6. Monitoring methodology that can be used for PCBs, RCl, and TPM was described in Section 2.3, which also describes analytical methodology. Section 2.3 describes recommended methodology (59), as well as other techniques that have been used. Monitoring methodology proposed by the facility operator should be compared with that described in Section 2.3.

4.2.2 Monitoring, Sampling, and Analysis

A clear distinction must be made between "monitoring", which is a continuous determination of some parameter and "sampling" which involves the collection of a discrete sample for subsequent analysis to determine some relevant parameter. The following section presents the parameters which must be monitored or sampled for subsequent analysis. In some cases, the regulations use the terms interchangeably and this discussion will clarify those cases.

4.2.2.1 PCB Waste Characterization--

Section 3.2.6 discussed methods for obtaining a sample for waste characterization. The regulations discuss, in the Preamble to the PCB

Regulations, the method of analysis for PCBs. ASTM D3304 presents a method for analysis of air, water, soil, and sediments for PCB content. At the time of this document, no standard procedure has been accepted for PCB analysis of the waste itself, although the EPA has provided interim guidance (60) to all Regional Offices. The Regional Administrator must evaluate the method proposed in each Trial Burn Plan for analysis of PCB content.

4.2.2.2 Pre-test Site Survey--

If the incinerator operator will be performing the sampling and monitoring effort for the Trial Burn, a pre-test site visit will not be necessary. Some incinerator operators, however, may not be qualified for or interested in performing such efforts. In most cases, therefore, an independent contractor will be hired to conduct monitoring, sampling, and analysis during the incinerator Trial Burn. In these cases, while not required by the PCB Regulations, the Regional Administrator should require the contractor to make a pre-test site survey.

If the pre-test site survey is not completed prior to submission of the Trial Burn plan, evaluation of the monitoring, sampling/and analysis portions of the Trial Burn plan will be incomplete, since modifications which may be required by the contractor will not be known to EPA personnel. Therefore, in cases where the sampling and monitoring effort is being conducted by someone other than the incinerator operator, the Trial Burn plan should include a report from the contractor that will conduct the actual work. This report on the pre-test site survey should include assessment of the adequacy of the sampling locations, facilities (such as power, water, if needed, shelter, etc.) available, compatibility with sampling equipment, and modifications to the incinerator of sampling and monitoring equipment necessary to collect the Trial Burn data.

4.2.2.3 Monitoring--

While the PCB Regulations do not specify the parameters which should be monitored during the Trial Burn, they should, at a minimum, include all parameters which must be monitored or sampled during actual PCB incineration. Table 22 indicates monitoring requirements. In addition to feed rates of the waste and fuel, incinerator temperature and scrubber effluent discussed above, the PCB Regulations state the parameters which should be monitored and/or sampled during the first use or first use after substantial modification of a facility for PCB incineration. These parameters are: oxygen (O_2), carbon monoxide (CO), carbon dioxide (CO_2), oxides of nitrogen (NO_x), hydrochloric acid (HCl), total chlorinated organic compounds (RCl), PCBs, and total particulate loading of the stack emissions. Section 761.40 (1)(7) states that oxygen (O_x) and carbon monoxide (CO) must be monitored continuously and that "Monitoring for CO_2 shall be periodic, at a frequency specified by the Regional Administrator". A strict interpretation of this requirement eliminates Orsat analysis of grab samples for CO and O_2, since such a technique is not "continuous". Intermittent sampling of the stack gas or integrated samples taken by slowly filling a sample container for subsequent CO_2 analysis are less than satisfactory. In most cases since the former may not be representative of the long-term stability, and the latter integrates the value smoothing out high or low values. Thus, continuous CO_2 analysis, while not required by the PCB Regulations, is preferable to grab samples during a Trial Burn to establish the variability of CO_2 content of the stack gas. When coupled with the CO data, a continuous record of the combustion efficiency can be obtained.

4.2.2.3.1 Equipment--Monitoring equipment for CO and O_2 have been discussed in Section 2.4.1; fuel and waste feed rate monitoring in Section 4.1.5; and temperature of the incinerator in Section 4.1.2. These are the parameters which require continuous monitoring, and the Test Burn plan should specify the type, manufacturer, and model of each instrument to be employed. Supporting documentation should be appended to the Trial Burn plan describing each instrument in detail.

4.2.2.3.2 Use of real-time data --Continuous monitors produce a "real time" analog signal, which is typically recorded on a strip chart. A hard copy of the data is necessary for documentation purposes. Data reduction is done by hand. An additional piece of equipment which can assist in the evaluation of continuous data is a data-logger. Such devices sample the output of the monitor at discrete (pre-programmed) intervals and print the data on paper tape or store the data on magnetic tape. Data reduction is performed manually, or a small computer can be used to reduce the data. A computer has the advantage that data reduction is rapid, and the data can be integrated, or "smoothed" to eliminate some of the problems described in the preceding section. A hard copy of the data should still be obtained, however. "Real-time" data obtained from continuous monitors requires that certain judgements be made on the acceptance of temporal variations in the signal. For example, brief decreases in CO_2 or increases in CO response will lower the calculated instantaneous combustion efficiency. The amount of the change, duration of the change, and frequency of such changes are criteria which must be considered when evaluating real-time data. The flow of PCB wastes must, by regulation, be interrupted when oxygen content of the incinerator decreases below a preset value (2% or 3%). A decision must be made as to how long the response must stay below the minimum before the flow is stopped. This time span should be linked to the response time of the method for correcting the problem. Section 761.40(a)(9) provides the operator with the opportunity to address this concern by offering a contingency plan for approval by the Regional Administrator. Such approval can only be made on a case-by-case basis.

4.2.2.4 Sampling--

Sections 761.40(a)(6) and 761.40(a)(7) state the parameters which must be determined in the stack gas at the start of a routine PCB burn. In addition, samples must be obtained of the scrubber effluent, the fuel, and the waste being burned. All effluent streams from such treatment processes should be sampled and analyzed for RCl and PCBs. This should be the minimum required for acceptance of a Trial Burn plan as well.

4.2.2.4.1 Stack sampling--The purposes of stack sampling are: 1) to monitor the incinerator operation conditions (O_2, NO_x, HCl, and particulates); 2) to determine the combustion efficiency of the incinerator (CO and CO_2); and 3) to determine the efficiency of PCB destruction during waste incineration (RCl and PCBs). A sampling location should provide adequate access to the ducting to permit the determination of the stack velocity profile so that a representative sample can be obtained. Two methods for sample acquisition can be employed in stack monitoring. If sufficient ports are available, short sampling periods at several points across two diamters of the stack (EPA Method 1) have been used to collect a representative sample. Another method is to sample isokinetically a single point chosen to be "average" on the basis of the velocity profile. Stack sampling techniques and locations have been discussed in Sections 2.3.1.1 and 4.1.4.1. The Trial Burn plan should be evaluated according to these discussions.

The time required to collect an adequate sample is dependent on several factors such as the sample flow rate, stack flow and concentration, and sensitivity of the detection device. The Trial Burn plan should indicate projected sample times. An estimate of the sample times required for collection of stack samples can be back-calculated from the detection limit of the analytical technique as follows: If the incinerator destruction efficiency is defined as:

$$DE = 100 \left[\frac{PCB_{in} - PCB_{out}}{PCB_{in}}\right]$$

In the "worst case", the amount of PCBs in the stack gas would be the amount of PCB being burned times 0.000001, assuming 99.9999% gas phase destruction efficiency, as required for non-liquid PCBs. Although not stated in the PCB Regulations, 99.9999% gas phase destruction efficiency should apply to liquid PCB wastes burned in an Annex I incinerator, as well as to non-liquid PCBs.

Detection limits for PCBs range from 25 ng to 10 μg, depending on the analysis method, and should be specified in the Trial Burn plan. Calculation of the minimum stack sampling time for PCBs can then be made assuming a factor of, for example, 3 more than the detection limit should be collected in the sample from the equation:

$$T = \frac{DL \times V}{0.00001\ F \times S} \quad (\times 3)$$

where: T = sampling time, sec

DL = PCB detection limit, g

V = volumetric flow rate of stack gas, $m^3 sec^{-1}$

F = feed rate of PCB waste, $g\ sec^{-1}$, and

S = sample flow rate, $m^3 sec^{-1}$

Since the same train can be used for HCl, RCl, PCB and total particulate matter, calculation of the sampling time should be made on each species and a time selected which allows collection of a sufficient quantity of all species without overloading any individual substance (for example total particulate matter). Three trains are suggested (60): one for PCBs, one for RCl, and one for HCl and total particulate matter.

The above equation can also be used to calculate the minimum PCB feed rate, since sufficient PCBs must be collected in the sample to exceed the detection limit. In other words, if

$$F < \frac{DL \times V}{0.000001 \times T \times S} \ (\times 3),$$

then an accurate determination of the destruction efficiency cannot be made because the quantity of PCBs collected will be below the detection limit.

In evaluating the Trial Burn plan, the Regional Administrator should:

- Determine if the number of tests is adequate (one background and three PCB tests are recommended)
- Determine if the sampling rates and durations are adequate:
  - one hour at 21 to 28 lpm (0.75 to 1 cfm) is typical for TPM and HCl
  - 4 hours at 21 to 28 lpm (0.75 to 1 cfm) is typical for PCBs and RCl by Modified Method 5 train

4.2.2.4.2 Liquid effluent sampling--In order to obtain a representative sample, the liquid streams should be sampled at 30 to 60 minute intervals if they are known to be reasonably homogeneous. It is sufficient to composite the samples taken after the burn has terminated. Samples taken prior to introduction of PCBs will serve as background samples, and those taken after the burn will determine whether hysteresis, or "memory" occurs (holdup of PCBs in the equipment and subsequent purging when PCB feed is terminated). Use of automated samplers is advised. Samples should be stored in appropriate containers prior to analysis, and the Trial Burn plan should indicate the sampling schedule, equipment, and the methods of compositing, storing, and shipping samples prior to analysis.

4.2.2.4.3 Solid effluent sampling--The collection of solid samples was discussed in Section 2.3.1.4 and sampling locations in Section 4.1.4.3. The Trial Burn plan should specify the method for sampling, compositing, and storing the solid samples.

4.2.2.4.4 Ambient air sampling--The PCB Regulations do not require ambient air sampling. However, the determination to require ambient air sampling or plume dispersion modeling is at the discretion of the Regional Administrator.

Ambient air sampling for PCBs preferably involves emplacement of high volume samplers, using polyurethane foam to trap PCBs, as described in Section 2.3.1.2. In order properly to emplace such samplers, local meteorological data (wind speed and direction) need to be considered. Also, the results of plume dispersion modeling can be used to emplace monitors, e.g., at the predicted location of the plume touchdown. Additional, general considerations for ambient air sampling are given below.

Sampling devices should be located at ground level, downwind of any structures containing PCB waste, including the incinerator. There should be no obstructions between the structure and the sampler, the inlet of which should be approximately 4 to 5 feet above ground to reduce the entrainment of soil. If the soil is suspected of contamination by PCBs, a sample of the soil around the sampler should be taken for analysis.

Meteorological data should be collected to permit proper location of the sampling devices. A single meteorological sampler in a location free from obstructions will suffice. Wind shifts of ± 30° from the direction initially chosen as "downwind" can be tolerated before the samplers must be repositioned. High winds or precipitation during the burn will reduce the validity of ambient samples, and the Trial Burn plan should address this possibility. At least one sampler should be located upwind of any potential PCB source. This unit will collect samples which will be used to determine the quality of the air entering the plant and which will be considered as blanks. The air upwind and downwind of the facility should be sampled simultaneously prior to incineration of PCBs and during the Trial Burn. Proposed locations for the ambient air monitors should be clearly indicated on the facility diagram. Sampling durations and schedules should be specified in the Trial Burn plan.

4.2.2.5 Analysis--

The Trial Burn plan should describe in some detail the analytical protocol to be followed for determination of: 1) PCBs, 2) organochlorines, and 3) total particulate matter. Section 2.3.2 described both the recommended methodology (60) and methodologies used in various PCB test programs.

Briefly, the methodology for PCBs involves the following steps:

- Extracting the various samples and drying the extracts
- Combinations as appropriate (e.g., combine extracts of particulate filter, impingers, and Florisil)
- Cleanups (e.g., partitioning with sulfuric acid, column chromatography on silica gel)
- Concentration to 25-ml and splitting into three 5-ml aliquots and one 10-ml aliquot
- Perchlorination of the 5-ml aliquots to decachlorobiphenyl followed by analysis by gas chromatography with electron capture detection
- Gas chromatography/mass spectrometric analysis of the 10-ml aliquot for confirmation of PCBs

While there are other, and perhaps better analytical methodologies (e.g., that proposed by Levins, et al. (97)), it is recommended that the methodology described by Beard and Shaum (60) in EPA's Interim Manual be employed in order to achieve consistency and comparability of Trial Burn results.

4.3 EVALUATION OF TRIAL BURN DATA

The object of obtaining data during a Trial Burn of PCBs or PCB-Items is to provide information needed for predicting, maintaining, and documenting conditions for the safe disposal of PCB waste materials and for the protection of personnel and environment.

This section, and the accompanying Appendix C, detail the treatment and evaluation of analytical data which are necessary to derive required process parameters, such as residence time and combustion and PCB destruction efficiency. Also included is a discussion of how these data relate to important process parameters, thus indicating how adequately the combustion process is being monitored.

Data gathering will begin with the analysis of PCB waste prior to incineration to determine handling, process control, and combustion requirements. During incineration, various indicators of the combustion process will be monitored by on-line gas analyzers, temperature measurement instrumentation, and flow rate measurement devices. Samples will be collected for laboratory analyses to determine waste destruction efficiency. On-line gas analyzers and collected samples will also be used to monitor pollutants in the final air emissions, liquid effluents, and solid residues from the disposal system in accordance with the PCB Regulations. Also for personnel safety, as well as for the protection of the surrounding populace, meteorological conditions may have been monitored to prevent undesirable exposure to toxic or corrosive emissions.

The aforementioned activities require specialized equipment and facilities. Because of the ease with which the resulting data can be accumulated on a data logger or a minicomputer, it is assumed that the measurements by monitoring instruments will be digitized for interfacing with one of these devices. Visual observations and data resulting from laboratory analyses can be manually logged. The data logger or computer can then be used tc store, reduce, and analyze the raw data. Outputs from either one of these devices will include information needed by the incinerator operator and also complete reports of raw or reduced data. If data logger or minicomputers are not used, manual reduction of data will have to be performed.

The information resulting from the above data will be used for:

- Waste feed characterization
- Combustion temperature determination
- Combustion efficiency determination
- Waste destruction efficiency determination
- Residence time calculation
- Facility approval

The information regarding waste feed characterization is required to answer important questions that must be determined prior to incinerating the PCB waste, such as: Will the waste support combustion? Can the waste be mixed safely with other wastes? Should the waste be fed as solid or as a liquid? Will operation of the control device be required? What compounds should subsequently be measured to determine waste destruction efficiency?

4.3.1 Completeness of Data

Prior to the determination of the aforementioned information, it is essential that the data obtained during a Trial Burn be reviewed for completeness. In this Section, a list of parameters is provided to ascertain that minimum data requirements to meet PCB Regulations were obtained during the Trial Burn.

In Table 24 a summary of the types of data required to evaluate a Trial Burn is listed. It must, however, be noted that for each Trial Burn data requirements may not conform to the data listed in Table 24 because of the variability in the type of incinerators, type of control equipment, and PCB waste at specific sites.

4.3.2 Data Reduction

As mentioned earlier, the data collected during the Trial Burn are used to determine residence time, destruction efficiency, combustion efficiency, and other operational parameters specified in the PCB disposal regulations.

Oxygen, carbon monoxide, carbon dioxide, and total hydrocarbons are monitored and serve as a basis for monitoring combustion efficiency. O_2 is monitored because it is a critical parameter for tuning the combustion process to desired stoichiometric conditions. CO and total hydrocarbons (HC) are monitored to provide immediate information regarding the adequacy of combustion, and O_2 is monitored so that an average combustion efficiency can be determined.

Combustion efficiency is calculated based on the following equation:

$$CE = \frac{C_{CO_2}}{C_{CO_2} + C_{CO}} \times (100) \qquad (1)$$

where CE = combustion efficiency
C_{CO_2} = percent carbon dioxide in the flue gas stream, and
C_{CO} = percent carbon monoxide in the flue gas stream

(The equation in the PCB Regulations (on page 44 FR 31551) is incorrect. An

TABLE 24. TYPES OF DATA FROM TRIAL BURN

I. Summary of Feed Rates
(In and out of the incinerator)

- Liquid Waste
- Liquid PCB
- Solid PCB
- Supplementary Fuel
- Miscellaneous Waste
- Scrubber Water
- Solid Residue

II. Analysis of Fuels
(This includes PCBs and PCB-Items, Fuels, etc.)

- Carbon Content
- Hydrogen Content
- Chlorine Content
- Oxygen Content
- Ash Content
- Heating Value
- Molecular Weight

III. Combustion Gas Analysis

- O_2 Content
- CO_2 Content
- CO Content
- NO_x Content
- HCl Content
- PCB Content
- RCl Content
- H_2O Content
- Particulates Content
- Temperature of gas
- Volumetric flow rate

IV. Properties of Liquid Waste

- Density
- Heat Content (HHV)
- Chlorine Content
- Ash Content
- pH Value
- Sulfur Content

V. Incinerator Information

- Volume of Combustion Chamber
- Temperature in the Combustion Zone
- Temperature of Input Feed
- Temperature of Input Air
- Volume of Input Air

open parenthesis should be added after the equals sign and a close parenthesis before the multiplication sign.)

The PCB Regulations do not require calculation of destruction efficiency. Instead, they require determination that PCB emissions to the air not exceed 1 mg per kg of PCBs fed (when burning non-liquid PCBs only). It is recommended, however, that destruction efficiency be calculated and reported because it is a widely used figure of merit and because it will enable the environmental community to compare present with past incineration tests. It should be noted whether a destruction efficiency derived from a PCB Trial Burn is an overall one (air, water, and solid) or gas phase only. Destruction efficiency is calculated using the following equation:

$$100 \times \frac{W_{in} - W_{out}}{W_{in}} \qquad (2)$$

where DE = destruction efficiency

W_{in} = amount of PCB into the incinerator, m^3/sec or /hr, and

W_{out} = amount of PCB exiting the incinerator, m^3/sec or /hr

Residence time within incinerators is a function of the combustion temperature and the volume of the unit combustion chamber. Combustion temperatures within these units are obtained by either direct (pyrometer) or indirect (wall thermocouple - pyrometer correlation) temperature readings.

Residence or dwell time (Section 2.2.6) is usually calculated from an equation similar to the one presented below (corrected from standard conditions):

$$t = \frac{V}{Q(T/Tstd)} \qquad (3)$$

where t = residence time, sec

V = volume of incinerator, m^3

Q = volumetric flow rate, m^3/sec

T = temperature in combustion zone, K, and

Tstd = standard temperature, K

Sample calculations of residence time, combustion efficiency, and destruction efficiency are provided in Appendix C.

4.3.3 Data Assessment

Following data reduction, a review should be made to assess the validity and representativeness of the data. This review should include:

- Engineering assessment - Determine any periods of anomalous operation, such as during burner cleaning, start up, shut down, or inoperative periods. Remove data taken during periods of anomalous operation. These data can be used to characterize transient effects but should not be included in characterizing normal operations.
- Statistical testing - After removal of data from anomalous operation, statistical testing for outliers should be performed. The Dixon Outlier Test (140) is recommended. A basic assumption in using the Dixon Test is that data are normally distributed, a common assumption.
- Data quality assessment - Calibration data for thermocouples, flow rate devices, gas monitors (CO, CO_2, O_2, NO_x), stack samplers, instrumentation, and etc., should be reviewed for acceptability in terms of recency of calibration and results.

Data satisfying the above assessment can then be used to characterize the Trial Burn. A suggested means of data treatment for characterizing the Trial Burn and determining whether or not approval is warranted involves calculating tolerance limits.

The tolerance limit is a statistical method of examining the excursions of individual measurements about the mean value. It is recommended that the 0.99/0.95 tolerance limit be used. This nomenclature means that 99% of the data points will fall within the limits in 95 of 100 times. In other words, the recommended tolerance limit will be such that, at most, 1% of the data points will fall outside the limit upon repeated measurements, 5% of the time.

In cases for which only a maximum (or minimum) value is of interest, the one-sided tolerance limit should be used. Where both maximum and minimum values are of interest, the two-sided tolerance is used. Tolerance limits are defined as:

- Upper limit = $\bar{x} + K_1' s$ (1-sided)
- Lower limit = $\bar{x} - K_1' s$ (1-sided)
- Upper/lower limit = $\bar{x} \pm K_2' s$ (2-sided)

where $\bar{x}$ = calculated average

s = calculated standard deviation

n = number of data points in average

K_1 = 1-sided tolerance factor for n-1 degrees of freedom at $p = 0.99$ probability and $\gamma = 0.95$ confidence

K_2 = 2-sided tolerance factor under same conditions as K_1.

In some instances it might be useful to characterize the mean of a set of data rather than excursions of individual data points about the mean. In these instances, the confidence interval can be calculated. The confidence factor commonly used for calculating the confidence interval is 95%. The confidence interval is:

$$\mu = \bar{x} \pm \frac{ts}{n}$$

where u = true population mean

$\bar{x}$ = average

s = standard deviation

t = "student's" statistic at 95% confidence and (n-1) degrees of freedom

n = number of measurements comprising the mean

The confidence interval provides a range of values within which the true mean of the population sampled should lie with 95% confidence upon repeated testing under the same test conditions.

4.3.3.1 Operational and Monitoring Data--

Adequacy of operational and monitoring data can be assessed by the procedure described above:

- Engineering assessment
- Statistical testing
- Quality assessment
- Tolerance limit (or confidence interval).

A numerical example of tolerance interval is given below. For the first test day during the at-sea incineration of Herbicide Orange (33, Table 19), the wall temperatures of the starboard incinerator averaged 1225 ± 19°C (one standard deviation, average of 24 hourly measurements). Assume that the lower limit was to be 1100°C. The lower, one-sided, tolerance limit is calculated to determine the minimum temperature below which only one measurement in 100 is expected to fall with 95% confidence. From Reference 141, $K_1 = 3.181$ for 0.99/0.95 and 23 degrees of freedom. The lower tolerance limit is:

$$LL = 1225°C - 3.181 \times 19°C$$

$$LL = 1164°C$$

Thus, for this set of thermal data, one has 95% confidence that not more than one measurement in 100 will be below 1164°C, and one would conclude that this was an acceptable thermal measurement.

4.3.3.2 Sampling Data--

Assessment of the adequacy of sampling data (i.e., for PCBs, RCl, and TPM) is made by: 1) examination of the sampling logs, and 2) consideration of the analytical results.

Detailed sampling logs will be submitted as part of the Trial Burn data. The following information should be present:

- Stack samples - name of stream; date and start/stop time of test; port location(s) and traverse points; flow rates, temperature, pressure drops, and times at each point; initial and final impinger volumes; initial and final weight of silica gel; and process data on combustion gas flow rate
- Solid or liquid grab samples - name of stream; name of sample; date, time, and location; approximate amount of sample; description of appearance; and pertinent process data to enable the analyst to calculate the fraction of the tested stream represented by the sample
- Solid or liquid composite samples - name of stream and sample; date, time span over which the sample was collected; the volume of each increment to the composite; tested composite volume; description of appearance; and pertinent process data to enable the analyst to calculate the fraction of the total stream represented by the composite sample

The absence of any of the above information may hinder subsequent analysis or invalidate the results of the Trial Burn. For example, if the amount of PCBs fed or if the volume of stack gas sampled is lost or not acquired, it will not be possible to determine if emissions of PCBs while incinerating non-liquid PCBs exceed 1 mg/kg. The second stage of evaluating the adequacy of sampling data involves analytical results, which are described below.

4.3.3.3 Analytical Data--

The analysis portion of a Trial Burn report should describe in detail the following items:

- Procedures
    - Extractions, dissolutions
    - Cleanups
    - Analyses
- Instrumentation
- Quality control-quality assurance
    - Blanks and controls
    - Replicates
    - Spikes
    - Calibrations
    - Statistical treatment
- Results

A Trial Burn conducted as suggested in Section 4.2 will provide one stack sample and blank for PCBs on each of three days and a fuel oil background and blank. Corresponding liquid and solid effluent stream samples were also acquired. A sampling effort conducted as recommended permits the data analyst to assess the day-to-day variability (1 sample on each of 3 days).

The QA/QC program will enable the data analyst to determine the accuracy and precision of the results by: 1) corrections for blanks and controls, 2) use of calibration curves, and 3) statistical treatment of replicate analyses and spiked samples.

The overall validity of the sampling and analysis effort can then be assessed by a procedure similar to that used to assess operational data in Section 4.3.3.1 by calculating the tolerance limit.

4.3.3.4 Summary--

Table 25 presents a checklist of required Trial Burn results which must be achieved for approval to be granted.

TABLE 25. CHECKLIST OF TRIAL BURN RESULTS

	Parameters	Value(s)	Adequate	Inadequate
1.	Combustion temperature			
	a. Pyrometer			
	b. Wall thermocouple			
2.	Excess oxygen			
3.	Carbon monoxide			
4.	Carbon dioxide			
5.	Residence time			
6.	Combustion efficiency			
7.	Flow rate of PCBs			
8.	Mass air emissions of PCBs (non-liquid PCBs only)			
9.	PCB concentrations			
	a. Scrubber water			
	b. Solid residues			
10.	Destruction efficiency*			
	a. Liquid PCBs			
	b. Non-liquid PCB			
11.	NO_x			
12.	Total particulates			
13.	HCl control			
14.	RCL emissions			

* Value of $\geqslant$99.9999% inferred from PCB Regulation Preamble.

4.4 CRITERIA FOR INCINERATOR PERMIT APPROVAL

The operator of an incinerator is required to obtain written approval from the Regional Administrator prior to incineration of PCBs or PCB Items. Approval will be obtained according to the procedure described in Section 4.1 of this document. This procedure includes the sequential submittal of reports by the incinerator operator and the evaluation of these reports by the Regional Administrator, as illustrated in Figure 19.

The Regional Administrator approves an incinerator for disposal of PCB when he is satisfied the incinerator will meet the requirements of the PCB Regulations (40 CFR 761.40). These requirements are summarized briefly in Tables 26 and 27. The Regional Administrator's approval is contingent on evaluation of information submitted in an Initial Report by the incinerator operator. Guidelines to assist the Regional Administrator in the evaluation of the Initial Report to determine conformance of the incinerator system with requirements of the PCB Regulations are discussed in Section 4.1 of this document. Subsequent to evaluation of the Initial Report, and submittal of any other information required, the Regional Administrator may require that a Trial Burn be conducted before approval may be issued. Guidelines to assist the Regional Administrator in the evaluation and approval of the operator's Trial Burn plan are discussed in Section 4.2 of this document. Guidelines to assist the Regional Administrator in the evaluation of the Trial Burn results to determine conformance of the incinerator system with requirements of the PCB Regulations are discussed in Section 4.3 of this document.

The Regional Administrator will prescribe for approval additional requirements he find necessary to insure that the intent of the regulation is satisfied. Although such requirements may vary by Region and by source, it is expected that the Regional Administrators will normally impose requirements which are consistent with the guideline recommendations of Section 4.1, 4.2, and 4.3 of this document. The main elements of these additional requirements are summarized briefly in the following sections.

4.4.1 Design and Operational Criteria

To approve a facility, the Regional Administrator must be satisfied that the incinerator is capable of operating according to the basic requirements

TABLE 26. REQUIREMENTS FOR APPROVAL TO INCINERATE LIQUID PCBs

	DESIGN & OPERATIONAL CRITERIA	MONITORING & RECORD KEEPING CRITERIA	
a)	2 sec dwell 1200° C 3% stack O_2 or 1½ sec dwell 1600° C 2% stack O_2	CONTINUOUSLY: • Combustion temperature, Stack O_2 and CO	Collect & maintain information at facility for 5 year period
b)	Combustion efficiency ≥99.9%	PERIODICALLY: • Rate and quantity of PCBs Stack CO_2	
c)	Automatic Shutoff of PCB Feed * When: • temperature < (level prescribed above) • monitor failure for O_2, CO or CO_2 • measurement & recording failure for PCB feed • excess O_2 < (levels prescribed above) * or contingency measures, as approved by the RA.	At FIRST USE or after modification: • Stack O_2, CO, CO_2, NO_x, HCl, RCl, PCBs, total particulates	
d)	Water Scrubber (or alternative) for HCl Control	WHENEVER PCB ITEMS ARE RECEIVED, INCINERATED, OR TRANSFERRED • Date of receipt of PCBs received and source. • Date and description of PCBs incinerated or transferred to another facility. • Total weight of PCB materials received, transferred, and retained. • Identification of contents of PCB containers or transformers were transferred. • Idenfication of facilities to which PCB containers or transformers were transferred. • Total number and identification of types of PCB articles/equipment received, transferred, and retained. • Identification of facilities to which PCB articles/equipment were transferred • Total weight of solid residues from PCB incineration disposed to landfill and remaining.	Collect & maintain information for annual reports to EPA
e)	Storage facilities and operations per Annex III of 40 CPR Part 761		

TABLE 27. REQUIREMENTS TO INCINERATE NON-LIQUID PCBs

DESIGN & OPERATIONAL CRITERIA	MONITORING & RECORD KEEPING CRITERIA	
a) 2 sec dwell or 1½ sec dwell 1200° C or 1600° C 3% stack O_2 or 2% stack O_2 b) Combustion efficiency ≥ 99.9% c) PCB stack emissions ≤ 0.001 g/kg of PCB feed d) Automatic Shutoff of PCB Feed When: • temperature < (level prescribed above) • monitor failure for O_2, CO or CO_2 • measurement & recording failure for PCB feed • excess O_2 < (levels prescribed above)	CONTINUOUSLY: • Combustion temperature, Stack O_2 and CO PERIODICALLY: • Rate and quantity of PCBs Stack CO_2 At FIRST USE or after modification: • Stack O_2, CO, CO_2 NO_x, HCl, RCl, PCBs, total particulates	Collect & maintain information at facility for 5 year period
e) Water Scrubber (or alternative) for HCl Control f) Storage facilities and operations per Annex III of 40 CPR Part 761	WHENEVER PCB ITEMS ARE RECEIVED, INCINERATED, OR TRANSFERRED • Date of receipt of PCBs received and source. • Date and description of PCBs incinerated or transferred to another facility. • Total weight of PCB materials received, transferred, and retained. • Identification of contents of PCB containers or transformers were transferred. • Identification of facilities to which PCB containers or transformers were transferred. • Total number and identification of types of PCB articles/equipment received, transferred, and retained. • Identification of facilities to which PCB articles/equipments were transferred • Total weight of solid residues from PCB incineration disposed to landfill and remaining	Collect & maintain information annual report to EPA

of the PCB Regulations. The basic design and operational requirements (summarized briefly in Tables 26 and 27) are very broad; therefore, it may be necessary for the Regional Administrator to develop additional and more definitive guidelines to determine conformance of an incinerator facility with the regulation.

The facility operator must submit data indicating the residence time of PCB in the combustion zone meets the minimum requirement of the regulation. The operator should cite test data which he uses to calculate dwell time (e.g., volume of combustion chamber, mass flow rate of fuel and air, combustion chamber pressure) and show that adequate dwell time will be attained for the range of combustion conditions anticipated. Guidelines for evaluating dwell time are discussed in more detail in Section 4.1.1 of this document.

In the event of a PCB spill, the operator should perform sampling and analysis to determine the PCB contamination level associated with the spill, as covered by the facilities SPCC Plan. The spill and the associated media contaminating the spill should be removed to the boundary of the zone of contamination (any location where the PCB concentration exceeds 50 ppm) and disposed of by any of the acceptable methods prescribed in the PCB Regulations.

4.4.2 Monitoring and Record Keeping Criteria

To approve a facility, the Administrator must be satisfied that the incinerator is equipped with monitoring equipment which is able to meet the requirements of the regulation, and that the operator intends to maintain a record of the required information. The operator is required to maintain inventory data on the disposition of PCB materials on site, and monitor data for specified parameters measured continuously or at various different frequencies (see Table 26). The data are to be maintained for a period of at least 5 years, including a 5 year period after the facility is no longer used for storage or disposal.

In addition to the basic requirements specified in the PCB Regulations, the operator should monitor scrubber effluent samples prior to, during, and after PCB incineration. It is preferable that monitoring during incineration be conducted by collecting and analyzing composite samples from holding tanks, eliminating the need for frequent grab samples.

The operator should maintain a log of the combustion efficiency. It is preferable that a continuous record of the combustion efficiency be maintained. This is not impractical if a continuous CO_2 monitor is installed.

Temperature monitoring within the combustion zone may be conducted with thermocouples or radiation pyrometers when temperatures exceed the operating range of thermocouples. The temperature sensors should be shielded from the flame to avoid radiation effects on the temperature measurement. The temperature measurement should be conducted in at least two locations in the combustion chamber. The measurement should be accurate to within 100°C of the true temperature.

It is preferred that the liquid PCB waste feed rate be monitored by real-time measurement of the bulk flow rate and automatic continuous recording. A variety of standard devices are commercially available for this purpose. The flow rate of PCB into the incinerator is then calculated, based on the concentration of PCB in the waste and bulk flow rate. The PCB concentration should be determined by periodic sampling and analysis of the PCB waste feed. For solid PCB wastes, it will be required that the flow rate of waste solids be determined by weighing loads and monitoring the loading over regular intervals of 15 minutes or less. The actual feed rate of PCBs is determined based on the concentration of PCB in the solid waste feed (as determined by periodic sampling and analysis) and the bulk feed rate.

Waste residue from the incinerator may be monitored by using any suitable weight scale, and a log of the total weight of residue transferred to landfill shall be maintained by the operator.

4.4.3 Sampling and Analysis

The Regional Administrator will have available an Agency manual (60) prescribing preferred sampling methods and analytical procedures for the various parameters which are to be monitored at the incineration facility. These methods and procedures are discussed in Sections 2.3.1 and 2.3.2 of this document.

4.4.4 Waste Composition

Extensive testing has shown that PCBs are incinerated with destruction efficiencies greater than 99.99% when temperature, dwell time, and excess oxygen levels are maintained above certain minimum levels. The physical, chemical, and thermal properties of the PCB waste will affect the temperature, dwell time, and excess oxygen levels. However, waste feed rate, auxiliary fuel, excess air, and burner adjustments can be changed to maintain the required combustion conditions, and destruction efficiencies may be maintained at the desired minimum acceptable levels. Therefore, variations in the PCB content of the waste will not affect the destruction efficiency under the current regulation, and there is no need to restrict the PCB content of the waste.

4.4.5 Compliance Criteria

Continuing approval to operate an incinerator for the destruction of PCB waste depends on the operator maintaining compliance with applicable regulations. The Regional Administrator will determine whether such compliance is being maintained by reviewing incinerator performance reports submitted periodically by the operator. It is recommended that a performance report be submitted to the Regional Office every six months and should include summary and all required monitoring data corresponding to the periods when PCBs were incinerated. The report should include a summary of all occasions in which the operating conditions of the incinerator facility caused (or should have caused) a shutdown and an explanation of the cause of each such occurrence. The report should also document any spill occurrences, the associated contamination levels, and the remedial action taken. In addition, the operator must also prepare a separate document whenever the incinerator operation is shut down from failure of the monitoring equipment or failure of the incinerator to operate at the required conditions. This document will include an explanation of the shutdown occurrence and a description of any corrective measures taken to prevent a reoccurrence. The document must be submitted to the Administrator within 30 days of the shutdown occurrence.

The Regional Administrator will review all occurrences of suspended incinerator operation or violations of prescribed operating requirements to assess the associated potential impact and the risk of reoccurrence. If the Regional Administrator is not satisfied that the facility has taken proper remedial action to minimize the risk of reoccurrence or if the incident has resulted in excessive irreversible damage to the environment, approval for further operation of the facility will be suspended.

The Regional Administrator may also conduct periodic inspections of the facility to assure that the incinerator is in compliance with the regulations. The operator shall maintain monitoring data, PCB waste inventory records, and other pertinent documents or correspondence (per item (6) of Annex VI of 40 CFR 761) at the facility, and these records shall be available for inspection by the Administrator.

4.4.6 Waiver Criteria

Waiver of certain requirements of the PCB Regulations may be approved by the Regional Administrator as part of the approval when he is satisfied that the operation of the incinerator will not present an unreasonable risk of injury to health or the environment from PCBs. Such waivers are allowed on a site-specific basis and are contingent on the Regional Administrator's review of evidence submitted by the operator in request of the waiver.

It is recommended that EPA establish a policy regarding waivers that would:

- Require special review or consultation by a qualified team
- Maintain a file of waivers, waived criteria, and reasons for the waivers

5. EVALUATION OF HIGH EFFICIENCY BOILERS

One disposal option for liquids containing greater than 50 ppm PCB but less than 500 ppm PCB is thermal destruction in a high efficiency boiler. In general, high efficiency boilers must meet specific design and operational requirements set forth in the PCB Regulations at 40 CFR 761.10(a).

The notification and approval process for high efficiency boilers depends on the type of liquid being burned. A facility operator who intends to burn mineral oil dielectric fluid from PCB-Contaminated Transformers is required only to submit written notification of his intentions to the EPA Regional Administrator (RA) 30 days prior to the burn. No EPA approval is required. Thermal destruction of other liquid wastes containing 50 to 500 ppm PCB in high efficiency boilers requires not only written notice but also authorization by the RA. The different requirements stem from the fact that mineral oil dielectric fluids tend to have similar properties and high heat contents, while other liquids containing PCBs at low concentrations have properties that vary considerably and that may affect their combustibility.

This chapter is divided into four sections. Section 5.1 discusses aspects of facility design and operation and site-specific concerns which should be considered in evaluating notification information. Section 5.2 discusses the procedures that may be used to evaluate a Trial Burn plan, if one is offered. Should a Trial Burn take place, data should be evaluated based on the guidelines in Section 5.3. The technical criteria for approval of high efficiency boilers are summarized in Section 5.4.

5.1 EVALUATION OF NOTIFICATION INFORMATION

A checklist like that in Table 14 can be used in the evaluation of a high efficiency boiler system. Table 28 is a checklist for comparing required with actual values of the performance parameters specified in 40 CFR 761.10 for a Notification and Trail Burn. Notification information required by the PCB Regulations must contain, at a minimum, the following:

- The name and address of the owner or operator of the boiler and the address of the boiler

TABLE 28. INFORMATION FOR HIGH EFFICIENCY BOILERS*

Company Name ______________________ Location ______________________

Boiler Location ______________________ Date of PCB Burn ______________________

Type of PCB Waste to be Burned ____

Parameter	Requirement	Actual
Concentration of PCB in contaminated liquid	<500 ppm (Submit analysis)	ppm
Boiler capacity	$>50 \times 10^6$ Btu/hr	$\times 10^6$ Btu/hr
Boiler fuel	Natural gas, oil, or coal	
Normal boiler temperature	None	°F
Typical stack CO	None	ppm
Test stack CO	<50 ppm for gas, oil <100 ppm for coal	ppm ppm
Typical stack O_2	None	%
Test stack O_2	>3%	%
Gallons per year to be burned	None	gal.
CO monitoring	Continuous, >30,000 gal/yr Hourly, <30,000 gal/yr	
O_2 monitoring	Continuous, >30,000 gal/yr Hourly, <30,000 gal/yr	
Percent PCB waste of total feed to boiler (G)†	<10%	%
Boiler fuel geed measured, recorded	Every 15 minutes	
PCB-liquid feed measured, recorded	Every 15 minutes	
Combustion efficiency	>99.9%	
Analysis of PCB liquid, percent by weight, non-mineral oil dielectric fluid only	C, H, N, S, Cl, H_2O sediment, ash, heat content, carbon residue, flash point	C = % H = % S = % Cl = % H_2O = % Sediment = % Ash = % Heat content = Btu/gal Carbon residue = % Flash point = °C

---

*Adapted from Reference 139.

†Percent PCB liquid feed of total feed

PCB liquid feed rate: gal/hr __________ (A)
Heat content PCB liquid: Btu/gal ______ (B)
Boiler fuel feed rate: gal/hr __________ (C)
Boiler fuel heat content: Btu/gal ______ (D)
PCB liquid heat input: Btu/hr __________ (E) = (A) X (B)
Boiler fuel heat input: Btu/hr __________ (F) = (C) X (D)
Percent total fuel feed: % ____________ (G) = (E)/[(E) + (F)]

- The boiler rating in Btu/hour of heat input
- The carbon monoxide and oxygen concentrations encountered in boiler stack gases when it is operated in a manner similar to the manner in which it will be operated when burning PCB liquid wastes
- The type of equipment, apparatus, and procedures to be used to control the PCB feed rate and monitor carbon monoxide and oxygen concentrations

In addition, when liquid which is not mineral oil dielectric fluid is burned, the following items must be included in the notification:

- The type of waste to be burned
- The concentration of PCBs and of any other chlorinated hydrocarbons and the results of waste analyses performed using American Society of Testing and Materials (ASTM) methods for carbon, hydrogen, nitrogen, sulfur, chlorine, water, sediment, ash, heating value, carbon residue, and flash point
- The quantity of wastes estimated to be burned in a 30-day period
- An explanation of the procedures to be followed to insure that burning the waste will not adversely affect the operation of the boiler such that combustion efficiency will decrease

The owner or operator should supply enough information in the Notification to permit the Regional Administrator to evaluate whether the boiler will meet the design, operating, and monitoring requirements of the regulations and that proper reporting and recordkeeping procedures will be followed. For any requirements of the regulation which the operator requests a waiver, a detailed discussion should be included describing the waiver desired and the reasons for the request. If such a waiver is granted, the operator will be required to give additional notification to State and local authorities.

5.1.1 Boiler Design and Operation Evaluation

Aspects of boiler system design and operation should be evaluated using a systems approach. In evaluating a facility for approval to burn PCBs, general site description, waste feed system, boiler pollution control system, and process measurement and control systems should be considered as they affect the safe operation of the facility. Each of these topics is considered separately below.

5.1.1.1 General Site Description--

The location of the facility should be known with respect to industrial and residential areas and to surface waters. From this information, a general assessment of the environment affected by the disposal action can be made.

On-site equipment needed in the disposal action should be described. This would include transfer and storage facilities, boilers, and pollution control devices. Operations which are not part of the disposal action but which may be affected by it should be noted.

The goal of the site evaluation should be to determine how well the steps required in the PCB disposal action can be integrated at the chosen site, and whether the action has the potential to affect nearby activities or the environment.

5.1.1.2 Waste Feed System Evaluation--

As noted in Table 28, the PCB Regulations require that:

- Primary fuel feed rate, waste feed rate, and the total quantities of fuel and waste be measured and recorded at regular intervals of no longer than 15 minutes while burning liquid PCB waste
- The waste does not comprise more than 10 percent of the total liquid feed rate on a volume basis
- The above data, as well as monthly figures for the amount of PCB waste burned, be retained for five years at the boiler location
- The type of equipment and the procedures used to feed waste to the boiler be described in the operator's notice to EPA

The feed system evaluation should consider whether these regulatory requirements can be met, and additionally whether waste/fuel and waste/burner compatibility is likely, given the characteristics of the liquid PCBs and the primary boiler fuel. Compatibility is discussed below.

Waste and fuel may be fed separately to the burner or may be premixed, if both are liquids. If they are premixed, the liquids should be completely miscible in the proportion and at the temperature at which they will be mixed and fed to the burner. The viscosity and heating value of the mixture should be within the range the pump and burner are able to handle efficiently (see Section 4.1.1.3.2). Premix systems are advantageous in that only a single fluid is fed; however, should PCB flow need to be shut off immediately, the entire boiler may have to be shut down. A contingency plan should be drafted to avoid total disruption of boiler operations in the event PCB flow must be terminated. From this standpoint, separate firing of primary fuel and waste is preferable to a premix system. In the event PCB flow must be terminated, the boiler can continue to operate. Separate firing systems may not be advisable for pulverized coal-fired boilers with circular burners. Such firing practices are not normally recommended for long operating periods due to possible coke formation on the pulverized coal element. Coal-fired cyclone boilers, equipped to cofire oil, oil-fired boilers with dual-fluid burners, or gas-fired boilers with variable-mix multispud-type gas elements may be suitable for separate waste and fuel firing.

In some instances, the 10 percent limit for PCB flow may be safety waived, at the discretion of the Regional Administrator. This would be the case for PCB liquids with high heating values which, based on past experience, have good combustion characteristics.

5.1.1.3 Thermal Destruction Unit Evaluation--

PCB Regulations require that high efficiency boilers be designed and operated such that:

- The boiler is rated at a minimum of 50 million Btu/hr (15 MW) heat input rate
- If the boiler uses natural gas or oil as the primary fuel, the carbon monoxide concentration in the stack is 50 ppm or less and the excess oxygen is at least 3 percent when PCBs are being burned
- If the boiler uses coal as the primary fuel, the carbon monoxide concentration in the stack is 100 ppm or less and the excess oxygen is at least 3 percent when PCBs are being burned
- The mineral liquid PCB stream does not comprise more than 10 percent (on a volume basis) of the total fuel feed rate
- PCBs are not fed to the boiler unless it is operating at its normal operating temperature (i.e., no feed during start-up or shut-down)

- The owner or operator of the boiler:
  - Continuously monitors and records the carbon monoxide concentration and excess oxygen percentage in the stack gas while burning PCBs, or
  - If the boiler will burn less than 30,000 gallons of liquid PCB wastes per year, measures and records the carbon monoxide concentration and excess oxygen percentage in the stack gas at regular intervals of no longer than 60 minutes while burning PCBs
- The primary fuel feed rates, PCB waste feed rates, and total quantities of both primary fuel and waste fed to the boiler are measured and recorded at regular intervals of no longer than 15 minutes while burning PCBs
- The carbon monoxide concentration and the excess oxygen percentage are checked at least once every hour that PCBs are burned. If either measurement falls below the levels specified in the regulations, the flow of PCBs to the boiler shall be stopped immediately.
- PCBs are not burned when the boiler output is less than the output at which performance figures for carbon monoxide and oxygen were obtained
- Data on carbon monoxide and oxygen concentration are retained at the boiler location for five years.

Information in the notice filed with EPA should be evaluated to see that these requirements are met.

The regulations specify neither temperature or dwell time requirements, nor minimum combustion or destruction efficiencies. However, data may be included in the notice to EPA from which some of these parameters may be estimated. Typically, temperatures in the combustion zone of utility boilers range from 1430°C to 1675°C and in the furnace exit from 1090°C to 1402°C. Nominal dwell time in utility boilers generally ranges from 1.0 to 3.7 seconds. Oxygen concentration at the economizer exit varies from 0.9 to 4.0 percent (8). Thus, based on the criteria for Annex I incinerators, some boilers will meet the stringent requirements of Annex I and some will not. The Annex I requirements should be used in evaluating high efficiency boilers, not as requirements to be met, but as guideposts to determining the probable destruction efficiency capability of the boiler. Most boilers which meet the requirements for classification as a high efficiency boiler are capable of achieving combustion and destruction efficiencies of 99.9 percent or greater. Data may be available to estimate the normal combustion efficiency of the boiler, but PCB destruction efficiency estimates must be based on experience with similar wastes and boilers and on careful evaluation of information presented in the operator's notice to EPA.

Materials of construction in the boiler must be considered in evaluating boiler designs. The effect of increased chloride levels from PCBs will likely be quite small because of the low concentration of chlorine in the waste and the dilution of the chlorine content by the primary fuel. However, the resistance to chloride attack in the boiler and pollution control system varies for different fuel types and should be assessed. Coal-fired boilers are probably best equipped to withstand attack from HCl since the chloride content of coal sometimes reaches nearly 4000 ppm (102). Oil- and gas-fired boilers would potentially be more affected by the HCl generated from PCB combustion since the chloride content of oil and gas is much lower than for coal. Chloride attack is reduced at lower operating temperatures and pressures.

Boiler rating, age, and original design should be considered in the evaluation. The minimum rating of 50 million Btu/hr should be used as a guideline, but some slightly smaller industrial boilers may be well suited for PCB destruction while some larger boilers will be inadequate because of other design features. Older boilers tend to operate at lower temperatures than newer units. They will therefore be less suited to low heating value and/or low chloride content wastes and more suited to high heating value and/or high chloride content wastes. Many older boilers were originally designed for coal and then converted to oil or were originally designed for natural gas and converted to oil. Temperature profiles in these boilers are different from profiles typical of boilers originally designed for coal or oil.

5.1.1.4 Pollution Control System Evaluation--

The PCB Regulations do not require HCl emission control from high efficiency boilers. No additions to existing pollution control equipment should be necessary, solely for reduction of HCl from PCB combustion. If wet scrubbers are already installed on the boiler, HCl will be removed from the gas stream. The effect on materials of increasing the dissolved chloride content of the scrubber water should be considered if PCBs will be burned on a continuing basis.

Unlike Annex I incinerators, malfunction of the pollution control system should not be cause for shutting off PCB flow to the boiler.

5.1.1.5 Process Measurements and Control System Evaluation--

PCB Regulations applicable to high efficiency boilers require immediate shutdown of PCB waste flow to the boiler in the event that carbon monoxide or oxygen concentration in the stack gas drops below levels specified in the regulations. Thus, waste flow must be terminated if, during the periodic check (at least hourly) for carbon monoxide and oxygen concentration, oxygen is less than 3 percent (wet basis) or carbon monoxide is either 50 ppm or less (gas- and oil-fired boilers) or 100 ppm or less (coal-fired boilers). Although not required by the regulations, waste flow should be cut off in the event of:

- Malfunction of carbon monoxide or oxygen monitors or of PCB feed rate measuring devices, or
- Burner flameout (for oil- and gas-fired burners)

The type, location, and redundancy of equipment used in the process measurement and control systems have been discussed previously (Section 4.1.1.5.1).

For high efficiency boilers, existing control systems will be designed to match boiler output (usually in terms of steam production) to demand. Instantaneous cutoff of PCB flow might have severe adverse effects, not only on steam output but also on flame stability. Therefore, waste cutoff systems should be designed and operated so that the prime function of the boiler (steam production) is not impaired. Gradual switchover from waste/primary fuel to fuel alone will ensure nondisruptive boiler operation and will not significantly affect the environment.

5.1.2 Operational Data Capability

PCB Regulations require continuous monitoring and recording of carbon monoxide and oxygen concentrations in the stack gas for boilers which burn greater than 30,000 gallons of low concentration PCB wastes per year. For boilers burning less than 30,000 gallons per year, periodic monitoring at regular intervals of no longer than 60 minutes is required. Additionally, the flow rates and total quantities of primary fuel and waste must be measured and recorded for all boilers burning PCB wastes.

Although not required by the Regulations, another desirable measurement is the carbon dioxide concentration. If this measurement is taken along with carbon monoxide concentration, the combustion efficiency can be calculated. This would give another indication of the effectiveness of PCB destruction. If such a measurement is not normally taken, it should not be required as a condition for approval.

5.1.3 Waste Characterization and Feed Rate

The types of material which can be destroyed in high efficiency boilers, according to Section 761.10, are either mineral oil dielectric fluids containing 50 to 500 ppm PCBs or other liquids containing 50 to 500 ppm PCBs. In these cases, the PCB content of the liquid must be known prior to the burn. Exact determination of the PCB content can be obtained by analysis of samples collected according to methods described in Section 2.3.1.3. The primary fuel feed rate, PCB feed rate, and the total feed rates of both streams must be measured and recorded at intervals not exceeding 15 minutes when the PCB material is being burned. Further, the waste cannot comprise more than 10 percent (volume/volume) of the total fuel feed rate.

The notification or approval information should describe the method by which these flowrates will be measured. A wide variety of techniques and instruments are employed for process stream flow measurement. Table 21 is a partial list of flow monitors and manufacturers based on four different principles, each of which applies to certain liquid streams. The principal criterion for determining adequacy of the flow monitor should be accuracy.

Liquid PCBs which are not mineral oil dielectric fluid must be identified by type (e.g., hydraulic fluid, heat transfer fluid, etc.) and by chemical characterization. Such a characterization must be submitted with the original notice to EPA and must be done once a month as long as PCBs are burned. The waste must be analyzed for the following parameters using the indicated ASTM methods (in parenthesis):

- Carbon and hydrogen (ASTM D-3178)
- Nitrogen (ASTM E-258)

- Sulfur (ASRM D-2784, D-1266, or D-129)
- Chlorine (ASTM D-808)
- Water and sediment content (ASTM D-2709 or D-1796)
- Ash content (ASTM D-482)
- Heating value (ASTM D-482)
- Carbon residue (ASTM D-2158 or D-524)
- Flash point (ASTM D-93)
- PCBs and any other chlorinated hydrocarbons (no ASTM method specified)

The above data must be retained for five years at the boiler location.

Additionally, the following waste parameters should be measured in order to evaluate waste/fuel and waste/burner compatibility:

- Viscosity (vs. temperature)
- Density (vs. temperature)
- Miscibility with primary fuel, if primary fuel is liquid and fuel and waste are to be premixed.

5.1.4 Effluent Monitoring

The term "effluent" should refer to all streams leaving the high efficiency boiler, including boiler ash, electrostatic precipitator or baghouse flyash, scrubber waste, and stack emissions. The PCB Regulations require that only CO and O_2 be measured in the stack gas either continuously or, if the facility will burn less than 30,000 gallons of waste per year, at intervals not to exceed 60 minutes. Monitoring equipment for CO and O_2 discussed in Section 2.4 are applicable to high efficiency boilers as well, Table 7.

However, in order to determine that PCBs are being efficiently destroyed, an analysis of all influent and effluent streams should be performed at some time during PCB disposal, preferably prior to the time an approval is granted. In that case, the facility should have the ability to collect samples of all streams, similar to the monitoring capability of Annex I incinerators discussed in Section 4.1.3.

5.1.5 Sampling Locations

The facility is required to monitor CO and O_2 in the stack gas in order to verify that the conditions of the boiler remain constant and at some level guaranteed to destroy the PCBs present in the waste. The ideal place to sample the combustion gases is in the stack following any control devices. Since neither of these gases is affected by conventional effluent control devices, however, the location of such monitors is not critical, provided that no leaks exist in the system or that leakage can be accounted for.

5.1.6 Storage Capabilities

When storage of PCBs is required prior to disposal in a high efficiency boiler, PCBs must be stored in a facility which complies with Annex II. Requirements for such a facility are described in Section 4.1.6.

If PCBs or other hazardous wastes are not disposed of on a routine basis at a site, temporary storage facilities may have to be set up. In particular, this may involve construction of a temporary dike around PCB storage and transfer areas. The dike may be constructed with sand bags and lined with an impermeable plaster liner.

Compliance with Annex III storage requirements is not mandatory for PCB containers containing between 50 and 500 ppm PCBs, provided that:

- Storage is for a period no more than 30 days from the date of removal from service
- The date of removal from service and a notation that the PCBs so stored do not exceed 500 ppm is attached to the container, and
- A Spill Prevention, Control, and Countermeasures Plan has been prepared in accordance with 40 CFR 112.

5.1.7 Site Specific Concerns

It is expected that high efficiency boiler facilities will have even greater site-to-site variations than Annex I incinerators. Site specific concerns relevant to Annex I incinerators, discussed in Section 4.1.7, apply also to high efficiency boiler facilities. Thus, only several additional concerns are noted in this section for evaluation by the Regional Administrator.

The Trial Burn Plan should address (see Section 4.1.7 and Appendix B for more detail):

- Facility safety
  - Worker safety
  - Exposure control
- Spill prevention, control, and countermeasures plan

If the facility intends to burn PCBs infrequently or if the PCBs to be burned are not generated on-site, logistics, transportation, and spill prevention, control, and countermeasures should be addressed in the Notification. Further, the Notification should address public information mechanisms, especially if the facility is a utility.

5.2 EVALUATION OF TRIAL BURN PLAN

A Trial Burn is not required for burning mineral oil dielectric or other fluids of 50 to 500 ppm PCB content in a high efficiency boiler. It is, however, recommended that a Trial Burn be required for a high efficiency boiler in which the operator intends routinely to burn PCB fluids other than mineral oil dielectric fluids. This section provides guidelines and recommendations for evaluating a Trial Burn plan for a high efficiency boiler.

The PCB Regulations provide no guidance on a Trial Burn plan for high efficiency boilers. In a large extent, the requirements for a Trial Burn in an Annex I incinerator apply to high efficiency boilers. Thus, the evaluation of a high efficiency boiler Trial Burn plan follows the same criteria presented in Section 4.2. Since many high efficiency boilers employ devices to control stack emissions, such as cyclones, venturi scrubbers, high energy scrubbers, electrostatic precipitators, or fabric filters, effluent monitoring may be more complex than Annex I incinerators. Nevertheless, the need to determine the fate of the PCBs requires sampling and analysis of all influent and effluent streams.

A Trial Burn is not required for high efficiency boilers by the PCB Regulations; therefore, there are no specifications for technical content of a Trial Burn Plan. Thirty days prior to burning mineral oil dielectric fluids or other liquid PCB waste containing <500 ppm of PCBs, the EPA Regional Administrator must receive written notice of intent to burn. Table 28 shows information that must be contained in that written notice.

The criteria for acceptance of a facility to burn PCB wastes are defined in the regulations. The minimum acceptable boiler rating is 50 MBtu/hr. If the facility is coal-fired, the CO and excess oxygen in the stack gas must not be greater than 100 ppm and not less than 3 percent, respectively. For natural gas- or oil-fired boilers, the CO and O_2 content of the effluent gas must be 50 ppm or less and 3 percent minimum, respectively. The following sections discuss the information which should be contained in a Trial Burn plan and establish criteria by which such a plan may be evaluated.

5.2.1 Operational Data

5.2.1.1 Minimum Data Requirements--

The operational data which must be collected during a Trial Burn are the same as would be required for operation of the boiler during routine operation. At a minimum, the data must include:

- The PCB waste, fuel, and total feed rates at intervals not to exceed 15 minutes. The PCB waste feed rate must not exceed 10 percent of the total feed rate
- Boiler temperature
- Excess oxygen
- Carbon monoxide and carbon dioxide content of the stack gas

In addition, however, representative operational log sheets for the boiler and applicable control devices should be submitted for evaluation to determine whether sufficient data are logged to determine the normal operating conditions of the boiler prior to, during, and after the destruction of PCBs.

5.2.1.2 Adequacy of Equipment and Methodology--

Section 2.2.2 discussed the operation of high efficiency boilers. Specific items of equipment are required by the PCB Regulations for boilers destroying PCB wastes. The feed of PCBs must be interrupted whenever one of several failure modes are encountered. The Trial Burn Plan should address the method by which the equipment will meet and handle these conditions. The failure modes are:

- Excess oxygen drops below 3 percent
- CO exceeds 100 ppm for coal-fired boilers or 50 ppm for natural gas- or oil-fired boilers

- The temperature of the boiler is below "normal", as defined in 761.10(a)(3)(iii)(A)(5)
- The PCB waste comprises greater than 10 percent of the total flow of fuel and waste

Although not stated in the PCB Regulations, failure of the monitoring equipment for oxygen, temperature, or feed rate of fuel or PCBs should be grounds for terminating PCB input to the boiler, as it is with incinerators. The equipment used for such monitoring must, therefore, have not only demonstrable accuracy and reliability but also must have automatic cutoffs required to interrupt PCB feed.

5.2.2 Monitoring, Sampling and Analysis

The Regulations require only that CO and O_2 be monitored continuously and that the data be inspected on an hourly basis. It is recommended that, at least for a Trial Burn, a full investigation of all waste streams be made to determine the fate of PCBs being destroyed. The evaluation of a Trial Burn Plan for a high efficiency boiler then follows the same criteria as those for evaluation of a Trial Burn Plan for an Annex I incinerator. Since this overlap occurs, the following sections refer to the portion of Section 4 where the topic was discussed. Comments applicable to boilers are made where appropriate.

5.2.2.1 Waste Characterization--

Only liquid wastes are to be burned in high efficiency boilers, and these are discussed in Sections 4.1.6 and 4.2.2.1.

5.2.2.2 Pre-test Site Survey--

See Section 4.2.2.2.

5.2.2.3 Monitoring--

The monitoring scheme recommended in Section 4.2.2.3 applies to boilers as well.

5.2.2.3.1 Equipment--

See Section 4.2.2.3.1.

5.2.2.3.2 Use of Real-Time Data--

See Section 4.2.2.3.2.

5.2.2.4 Sampling--

The sampling effort required for a Trial Burn of an incinerator applies to a boiler as well. The effort may be larger because of greater use of pollution control equipment, but it should be required that all influent and effluent streams for each control system be sampled. Section 4.2.2.4 discusses this sampling.

5.2.2.4.1 Stack Sampling--

See Section 4.2.2.4.1.

5.2.2.4.2 Liquid Effluent Sampling--

See Section 4.2.2.4.2.

5.2.2.4.3 Solid Effluent Sampling--

See Section 4.2.2.4.3.

5.2.2.4.4 Ambient Air Sampling--

See Section 4.2.2.4.4.

5.2.2.5 Analysis--

The analysis of samples collected from a boiler will be conducted in the same manner as for samples collected from an incinerator, as discussed in Section 4.2.2.5. In addition, for PCB wastes other than mineral oil dielectric fluids, the waste must be analyzed for PCBs, other chlorinated hydrocarbons and the following components and characteristics, listed with their required method: carbon and hydrogen, ASTM D-3178; nitrogen, ASTM E-258; sulfur, ASTM D-2784, D-1266, or D-129; chlorine, ASTM D-808; water and sediment, ASTM D-2709 or D-1796; ash content, ASTM D-482; calorific value, ASTM D-240; carbon residue, ASTM D-2158 or D-254; and flash point, ASTM D-93.

5.2.2.5.1 On-Site, Off-Site--

See Section 4.2.2.5.1.

5.2.2.5.2 Analysis Equipment--

In addition to the equipment described in Section 4.2.2.5.2, sufficient equipment must be available to perform the ASTM procedures described in Section 4.2.2.5.

5.2.2.5.3 Analysis Methodology--

In addition to the methodology described in Section 4.2.2.5.3, the ASTM procedures in Section 4.2.2.5 must be performed on liquid PCB wastes other than mineral oil dielectric fluid.

5.3 EVALUATION OF TRIAL BURN DATA

Evaluation of data from a PCB Trial Burn in a high efficiency boiler can be performed in the same manner as for an Annex I incinerator. In order to minimize duplication of the discussion and guidelines presented in Section 4.3, this section will only discuss briefly the major steps of the process of evaluating Trial Burn data.

5.3.1 Completeness of Data

Prior to the data reduction effort, the Trial Burn data package should be examined for completeness. Table 29 is a list of types of data required of a Trial Burn recommended here for high efficiency boilers. Given the wide variation expected of high efficiency boiler facilities, particularly for control devices, several types of data in Table 29 are generic. For example, if the boiler were equipped with a scrubber, sufficient process data on the scrubber would have to be taken so that analysis of scrubber effluent streams could be converted into emission rates. Other entries in Table 29 are specifically required by the PCB Regulations.

5.3.2 Data Reduction

Results desired for characterizing a high efficiency boiler for routine burning of PCB-contaminated mineral oil dielectric fluid or for approval for burning other PCB-contaminated fluids are:

- Combustion efficiency
- PCB destruction efficiency
- PCB emissions
  - Air
  - Water effluent
  - Solid effluent
- Residence time

Numerical examples for combustion and destruction efficiencies and residence time are presented in Appendix C.

TABLE 29. RECOMMENDED TYPES OF DATA FROM TRIAL BURN IN A HIGH EFFICIENCY BOILER

- CO
- O_2
- CO_2
- Primary fuel
  - Feed rate
  - Quantity
- Waste-type
  - Feed rate
  - Quantity
- Boiler temperatures
- Stack sampling data
- Pertinent control device data
- Analytical data on PCB emissions

- Waste Composition*
  - C
  - H
  - N
  - S
  - Cl
  - Water
  - Sediment
  - Calorific value
  - Carbon residue
  - Flash point

*For non-mineral oil dielectric fluid wastes

5.3.3 Data Assessment

Section 4.3.3 presented a detailed discussion of a methodology for assessing the adequacy of Trial Burn data for Annex I incinerators. The major elements of the assessment process are given below:

- Completeness
- Engineering assessment for anomalous or non-representative operation
- Statistical testing to eliminate outliers
- Quality assessment of calibrations, standard, blanks, etc.

Data which are assessed as valid and representative by the above process are then used to characterize the adequacy of the Trial Burn for approval to burn PCBs. The suggested means of data treatment (see Section 4.4.3) is to calculate tolerance limits and compare these values with regulatory requirements.

5.4 CRITERIA FOR APPROVAL OF BOILERS FOR PCB DESTRUCTION

An operator of a boiler which is to burn minerial oil dielectric fluid containing a PCB concentration of 50 to 500 ppm must submit written notice to the Regional Administrator thirty days before the first burning of the fluid in the boiler. The Administrator will review the notice and may require additional actions by the operator prior to burning the waste fluid if he is not satisfied the boiler will meet the requirements of §761.10 of Subpart B of 40 CFR Part 761. The applicable requirements are summarized in Table 30.

An operator of a boiler which is to burn liquids other than mineral oil dielectric fluid, containing a PCB concentration of 50 to 500 ppm, must obtain written approval from the Regional Administrator prior to burning the PCB waste. Approval will be given by the Administrator when he is satisfied the boiler will meet the requirements of §761.10 of Subpart B of 40 CFR Part 761, as summarized in Table 31. The approval is obtained according to the procedure described in Section 3 of this document.

Guidelines to assist the Regional Administrator in the evaluation of the notification to burn mineral oil dielectric fluid or the request for approval to burn PCB fluids other than mineral oil dielectric fluid are discussed in Section 5.1 of this document. Subsequent to evaluation of the operator's notification or request for approval (as well as any other information required) the Regional Administrator may request, but cannot require, a Trial Burn be conducted before approval is issued. Guidelines to assist the Regional Administrator in the review and evaluation of the operator's Trial Burn plan are discussed in Section 5.2 of this document. Guidelines to assist the Regional Administrator in the evaluation of the Trial Burn results to determine conformance of the boiler with requirements of the Federal regulations are discussed in Section 5.3 of this document.

The Regional Administrator may prescribe additional safeguards he feels necessary to insure the intent of the regulation is satisfied. Although such requirements may vary by Region and by source, it is expected that the Regional Administrators will normally impose requirements which are consistent with the guideline recommendations of Sections 5.1, 5.2, and 5.3 of this

TABLE 30. REQUIREMENTS FOR BURNING PCB-CONTAMINATED DIELECTRIC FLUIDS IN HIGH EFFICIENCY BOILERS

Design & Operational Requirements

a) Boiler rating 50 x 10^6 Btu/hour

SPECS DURING PCB COMBUSTION

b)

Fuel Type	Stack O_2	Stack CO	Boiler Output Level
Nat gas or oil	≥3%	≤50 ppm	≥level corresponding to baseline tests
Coal	≥3%	≤100 ppm	≥ " " "

c) Feed rate of mineral oil dielectric fluid ≤10% of total fuel feed rate (by volume)

d) Mineral oil dielectric shall not be fed to boiler during start up or shut down

e) Based on periodic checks (at least once hourly), the feed of mineral oil dielectric fluid shall be shut off when concentrating of CO or O_2 are outside the allowable range.

Monitoring & Recording Requirements

Requirement	
a) Continuously: • Boiler operating temperature • Stack CO and O_2 (when boiler burns ≤30,000 gal/yr waste fluid per year, monitoring may be conducted at 60 minute intervals or less) • Boiler load factor b) 15 minute intervals: • Stack CO and O_2 (when boiler burns ≤30,000 gal/yr) • Primary fuel feed rate • Mineral oil dielectric fluid feed rate • Total feed rate c) Monthly: • Quantity of mineral oil dielectric burned for month	Collect & maintain information at facility for 5 years
d) Whenever PCB waste is Received, Burned or Transferred: • Date of receipt of PCB wastes received and source • Date and description of PCB wastes burned or transferred to another facility • Total weight of PCB waste received, transferred, and retained • Total weight of solid residue (from PCB burning) disposed to landfill and retained	Collect & maintain information for annual reports to EPA

TABLE 31. REQUIREMENTS FOR BURNING PCB-CONTAMINATED NON-MINERAL OIL DIELECTRIC FLUIDS IN HIGH EFFICIENCY BOILERS

Design and Operational Requirements

a) Boiler rating 50 x 10^6 Btu/hour

SPECS DURING PCB COMBUSTION

Fuel Type	Stack O_2	Stack CO	Boiler Output Level
Nat gas or oil	≥3%	≤50 ppm	≥level corresponding to baseline tests
Coal	≥3%	≤100 ppm	≥ " " "

c) Feed rate of mineral oil dielectric fluid ≤10% of total fuel feed rate (by volume)

d) Mineral oil dielectric shall not be fed to boiler during start up or shut down

e) Based on periodic checks (at least once hourly), the feed of liquid PCB waste shall be shut off when concentrations of CO or O_2 are outside the allowable range.

Monitoring & Recording Requirements

a) Continuously:

- Boiler operating temperature
- Stack CO and O_2 (when boiler burns ≥30,000 gal/yr waste fluid per year, monitoring may be conducted at 60 minute intervals or less)
- Boiler load factor

b) 15 minute intervals:

- Primary fuel feed rate
- Waste fluid feed rate
- Total feed rate
- Stack CO and O_2 (when boiler burns ≥30,000 gal/yr)

c) Monthly:

- Quantity of waste fluid burned for months
- Concentration in the waste of: carbon, hydrogen, nitrogen, sulfur, chlorine, water, sediment, ash, carbon residue
- Flash point and calorific value

} Collect & maintain information at facility for 5 years

d) Whenever PCB waste is received, burned, or transferred

- Date of receipt of PCB wastes received and source
- Date and description of PCB wastes burned or transferred to another facility
- Total weight of PCB waste received, transferred, and retained
- Total weight of solid residue (from PCB burning) disposed to landfill and remaining

} Collect & maintain information for annual reports to EPA

Sampling & Analysis Requirements

Constituent or parameter	Sampling/Analysis Method
PCB & other chlorinated hydrocarbons	Draft method in Interim Report on Sampling Methods and Analytical Procedures Manual for PCB disposal
Carbon, hydrogen	ASTM D-3178
Nitrogen	ASTM E-258
Sulfur	ASTM D-2784, D-1266 or D-129
Chlorine	ASTM D-808
Water, sediment	ASTM D-2709 or D-1796
Ash	ASTM D-482
Carbon residue	ASTM D-2158 or D-524
Calorific value	ASTM D-240
Flash point	ASTM D-93

document. The main elements of these additional requirements are summarized briefly in the following sections.

5.4.1 Design and Operational Criteria

Extensive testing has demonstrated that incinerators are capable of achieving a PCB destruction efficiency of 99.9 percent of greater when operating at high combustion efficiency (99.9 percent). It is a reasonable technical inference that large (>50 million Btu) well-designed boilers are capable of achieving at least 99.9 percent destruction efficiency, particularly when burning a "clean", high heat content waste such as PCB-contaminated mineral oil dielectric fluid. The operator must submit data indicating that sufficient combustion efficiency can be attained to meet the minimum requirement of the regulation. These data include carbon monoxide and excess oxygen levels in the stack when the boiler is operated in a manner similar to that which will be maintained when PCB wastes are burned. The operator must demonstrate that he will provide for shutoff of the PCB waste feed whenever the carbon monoxide or oxygen levels are not within the required levels.

In the event of a PCB spill, the operator should perform sampling and analysis to determine the PCB contamination level associated with the spill. The spill and the associated media containing the spill should be removed to the boundary of the zone of contamination (any location where the PCB concentration exceeds 50 ppm) and disposed of by any of the acceptable methods prescribed in 40 CFR 716.

5.4.2 Monitoring and Recording Criteria

To approve a facility, the Regional Administrator must be satisfied that the boiler is equipped with monitoring equipment which is able to meet the requirements of the regulation and that the operator intends to maintain a record of the required information. The operator is required to maintain inventory data on the disposition of PCB wastes on site and monitor data for specified parameters measured continuously or at various different frequencies (see Tables 30 and 31). The data are to be maintained for a period of at least 5 years, including a 5 year period after the facility is no longer used for storage or disposal.

It is preferred that liquid PCB waste feed be monitored by real-time measurement and automatic continuous recording. A variety of standard devices are commercially available for this purpose (Table 21). The PCB concentration in the fluid waste should be determined by periodic sampling and analysis of the waste feed.

Waste residue from the boiler may be monitored by using any suitable weigh scale, and a log of the total weight of residue transferred to landfill shall be maintained by the operator.

5.4.3 Sampling and Analysis

The Regional Administrator will have available an Agency manual prescribing preferred sampling methods and analytical procedures for the various parameters which are to be monitored at the boiler facility. These methods and procedures are discussed in Section 2.3.2 of this document.

5.4.4 Compliance Criteria

Continuing approval to operate a boiler for the destruction of PCB liquid wastes depends on the operator maintaining compliance with applicable regulations. The Regional Administrator will determine whether such compliance is being maintained by reviewing reports submitted periodically by the operator. It is recommended that a report be submitted to the Regional Office every six months which includes summaries of all required monitoring data corresponding to the periods when PCBs were burned. The report should also include a summary of all occasions in which the operating conditions of the boiler caused (or should have caused) a shutdown of the PCB feed and an explanation of the cause of each such occurrence, as well as any remedial actions taken. Such reports should also document any spill occurrences, the associated contamination levels, and the remedial actions taken.

The Regional Administrator should review all occurrences of suspended PCB feed (or violations of prescribed operating requirements) to assess the associated potential impact and the risk of reoccurrence. If the Regional Administrator is not satisfied that the facility has taken proper remedial action to minimize the risk of reoccurrence, or if the incident has resulted in excessive irreversible damage to the environment, approval for further operation of the facility will be suspended.

The Regional Administrator may also conduct periodic inspections of the facility to assure that the boiler is in compliance with the regulations. The operator must maintain monitoring data, PCB waste inventory records, and other pertinent documents or correspondence (per item (b) of Annex VI of 40 CFR 761) at the facility, and these records shall be available for inspection by the Administrator.

REFERENCES

1. Sissons, D. and D. Welti, "Structural Identification of Polychlorinated Biphenyls in Commercial Mixtures by Gas-Liquid Chromatography, Nuclear Magnetic Resources and Mass Spectroscopy", J. Chromatog., 60, 15 (1971).

2. Fuller, B., J. Gordon, and M. Kornreich, "Environmental Assessment of PCBs in the Atmosphere", Mitre Corp. Technical Report MTR-7210, Rev. 1, 1976.

3. U.S. EPA, Office of Toxic Substances, "Support Document/Voluntary Environmental Impact Statement and PCB Manufacturing, Processing, Distribution in Commerce, and Use Ban Regulation: Economic Impact Analysis", April 1975.

4. Nisbet, I.C. and A.F. Sarofim, "Rates and Routes of Transport of PCBs in the Environment", Environ. Health Perspect., 1, 21 (1972).

5. U.S. EPA, Office of Toxic Substances, "PCBs in the United States. Industrial Use and Environmental Distribution", EPA 560/6-76-005, February 1976.

6. "TLVs Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1979", American Conference of Governmental Industrial Hygienists, 1979.

7. Allen, R.N., "Trial Destruction of PCBs in an Electrical Utility Boiler", Proceedings of a Specialty Conference on Control of Specific (Toxic) Pollutants, the Florida Section of the Air Pollution Control Association, February 13-16, p. 275, 1979.

8. Electric Power Research Institute, "Disposal of Polychlorinated Biphenyls (PCBs) and PCB-Contaminated Materials", EPRI Report No. FP-1207, Vol. 1, October 1979.

9. Ottinger, R., J. Blumenthal, D. Dal Porto, G. Gruber, M. Santy, and C. Shih, "Recommended Methods of Reduction, Neutralization, Recovery, or Disposal of Hazardous Waste, Volume III: Disposal Process Descriptions, Ultimate Disposal, Incineration, and Pyrolysis Processes", EPA-670/2-73-053c (PB 224 582), August 1973.

10. Edwards, J.B., "Combustion: Formation and Emission of Trace Species", Ann Arbor Science, Ann Arbor, Michigan, 1974.

11. Ackerman, D.G., J.W. Adams, J.F. Clausen, N.J. Cunningham, E.H. Dohnert, A. Grant, J.C. Harris, R.J. Johnson, P.L. Levins, C.C. Shih, J.L. Stauffer, K.E. Thrun, R.F. Tobias, L.R. Woodland, and C.A. Zee, "Destroying Chemical Wastes in Commercial Scale Incinerators, Final Report Phase II", EPA Contract No. 68-01-2966, November 1977.

12. Ackerman, D.G., J.W. Adams, J.F. Clausen, J.C. Harris, R.J. Johnson, P.L. Levins, J.L. Stauffer, K.E. Thrun, R.F. Tobias, L.R. Woodland, and C.A. Zee, "Destroying Chemical Wastes in Commercial Scale Incinerators, Facility Report No. 6, Rollins Environmental Services", Contract No. 68-01-2966, June 1977.

13. Anonymous, "A Proposal by Rollins Environmental Services (TX), Inc., to the U.S. Environmental Protection Agency, Region VI, to Demonstrate the Incineration of Polychlorinated Biphenyls (PCB) at Their Facility in Deer Park, Texas, September 1979.

14. Anonymous, "The PCB Incineration Test Made by Rollins Environmental Services (TX) at Deer Park, Texas, November 12-16, 1979", Report by Rollins Environmental Services to EPA Region VI, June 1980.

15. Anonymous, "Test Plan for Incineration of PCBs at the ENSCO Facility in El Dorado, Arkansas", Test Plan 74 75-2, Prepared for Electric Power Research Institute, 15 August 1979.

16. Anonymous, "Disposal of Polychlorinated Biphenyls (PCBs) and PCB-Contaminated Materials. Volume 4: Test Incineration of Electrical Capacitors Containing PCBs", EPRI Report FP-1207, Volume 4, September 1980.

17. Adapted from Haile, C.F. and E. Baladi, "Methods for Determining the Polychlorinated Biphenyl Emissions from Incineration and Capacitor and Transformer Filling Plants", EPA-600/4-77-048, November 1977.

18. Adams, J.W., E.H. Dohnert, J.C. Harris, P.L. Levins, J.L. Stauffer, and K.E. Thrun, "Destroying Chemical Wastes in Commercial Scale Incinerators. Facility Report No. 5, 3M Company Chemolite Incineration System", July 1977.

19. Anonymous, The Chlorinated Dioxin Task Force, Michigan Division, Dow Chemical, USA, "The Trace Chemistries of Fire - A Source of and Routes for the Entry of Chlorinated Dioxins into the Environment", Copyright, Dow Chemical Company, 1978.

20. MacDonald, L.P., D.J. Skinner, F.J. Hopton, and G.H. Thomas, "Burning Waste Chlorinated Hydrocarbons in a Cement Kiln", Report to Fisheries and Environment Canada, Report No. EPS 4-WP-77-2, March 1977.

21. Ackerman, D.G., J.F. Clausen, and C.A. Zee, "Destroying Chemical Wastes in Commercial Scale Incinerators. Laboratory Analysis Results from the CHEM TROL/St. Lawrence Cement Facility Test", Contract No. 68-01-2966, November 1976.

22. Anonymous, "Emission Testing at Continental Can Company, Hopewell, Virginia, July 14-23, 1975", EPA Office of Enforcement, EPA-330/2-76-030, October 1976.

23. Anonymous, "Summary of PCB Emission Tests for Peerless Cement Company, Detroit, Michigan", December 1976.

24. Ahling, B., "Destruction of Chlorinated Hydrocarbons in a Cement Kiln", Environ, Sci. & Technol., 13, 1377 (1979).

25. Adapted from Prenco, Prenco Brochure, "The Modern Approach to Pollution Control", Pickands Mather and Company, Detroit, Michigan.

26. Adapted from Novak, R.G., "Eliminating or Disposing of Industrial Solid Wastes", Chemical Engineering, 177(21), 79 (1970).

27. Leighton, I.W. and J.B. Feldman, "Demonstration Test Burn of DDT in General Electric's Liquid Injection Incinerator", U.S. Environmental Protection Agency, Region I, December 1974.

28. Clausen, J.F., R.J. Johnson, and C.A. Zee, "Destroying Chemical Wastes in Commercial Scale Incinerators. Facility Report No. 1. The Marquardt Company", EPA Contract No. 68-01-2966 (NTIS PB 257 70916WP), October 1976.

29. Hutson, J.E., "Report on the Destruction of 'Orange' Herbicide by Incineration", Report to U.S.A.F. Environmental Health Laboratory, Kelly Air Force Base, Texas, April 1974.

30. Anonymous, U.S. Department of the Air Force, Final Environmental Impact Statement, "Disposition of Orange Herbicide by Incineration", November 1974.

31. Wastler, T.A., C.K. Offutt, C.K. Fitzsimmons, and P.E. Des Rosiers, "Disposal of Organochlorine Wastes by Incineration at Sea", EPA-430/9-75-014, July 1975.

32. Clausen, J.F., H.J. Fisher, R.J. Johnson, E.L. Moon, C.C. Shih, R.F. Tobias, and C.A. Zee, "At-Sea Incineration of Organochlorine Wastes Onboard the M/T Vulcanus", EPA-600/2-77-196, September 1977.

33. Ackerman, D.G., H.J. Fisher, R.J. Johnson, R.F. Maddalone, B.J. Matthews, E.L. Moon, K.H. Scheyer, C.C. Shih, and R.F. Tobias, "At-Sea Incineration of Herbicide Orange Onboard the M/T Vulcanus", EPA-600/2-78-086, April 1978.

34. Ackerman, D.G., "Destruction Efficiencies for TCDD During At-Sea Incineration of Herbicide Orange", EPA Contract No. 68-02-2660, March 1979.

35. Ackerman, D.G., R.J. Johnson, E.L. Moon, A.E. Samsonov, and K.H. Scheyer, "At-Sea Incineration: Evaluation of Waste Flow and Combustion Gas Monitoring Instrumentation Onboard the M/T Vulcanus", EPA-600/2-2-79-137, July 1979.

36. Adapted from Sebastian, F.P. and P.J. Cardinal, "Solid Waste Disposal", Chemical Engineering, pp. 112-117, October 14, 1968.

37. Hitchcock, D., "Solid Waste Disposal: Incineration", Chemical Engineering, 86(11) 185, (1979).

38. Whitmore, F.C., "Destruction of PCBs in Sewage Sludge During Incineration", NTIS No. PB 258162/7WP, 1976.

39. U.S. EPA, "A Study of Pesticide Disposal in a Sewage Sludge Incinerator", SW-116c, 1975.

40. Ackerman, D.G., J.F. Clausen, R.J. Johnson, and C.A. Zee, "Destroying Chemical Wastes in Commercial Scale Incinerators. Facility Report No. 3. Systems Technology", EPA Contract No. 68-01-2966, NTIS PB 265 540, November 1976.

41. Personal communication from Raymond Esposito, President, Union Oil Company, to D.G. Ackerman, April 1980.

42. Anonymous, "Destroying Chemical Wastes in Commercial Scale Incinerators. Facility Test Plans Volume II", NTIS No. PB 257 710/4 WP, July 1975.

43. Ferguson, T.L., F.J. Bergman, G.R. Cooper, R.T. Li, and F.I. Honea, "Determination of Incinerator Operating Conditions Necessary for Safe Disposal of Pesticides", EPA-600/2-75-041, December 1975.

44. Adams, J.W., J.C. Harris, P.L. Levins, J.L. Stauffer, K.E. Thrun, and L.R. Woodland, "Destroying Chemical Wastes in Commercial Scale Incinerators. Facility Report No. 2. Surface Combustion Division Midland Ross Corporation", NTIS No. PB 268 232, November 1976.

45. Hall-Enos, J. and S. Zelenski, "Test Plan for Evaluation of PCB Destruction Efficiency in Industrial Boilers", EPA Contract No. 68-02-3168, TD No. 9, March 1980.

46. Zelenski, S.G. and S. Haupt, "Evaluation of PCB Destruction in Industrial Boilers", Draft Final Report, EPA Contract No. 68-02-2607, Task No. 33, December 1979.

47. Adapted from "Steam: Its Generation and Use", 39th Edition, Babcock and Wilcox Company, New York, 1978.

48. Anonymous, "Destruction of a Dilute PCB-Contaminated Waste in a Coal-Fired High Efficiency Boiler at Tennessee Eastman Company", Report by Tennessee Eastman Company, December 1979.

49. U.S. EPA, 40 CFR Part 60, Federal Register, Vol. 41, No. 111, 8 June 1976, pp. 23076-23083.

50. Grant, D.M., "Open Chemical Flow Measurement Handbook", Instrumentation Specialties Company, 1978.

51. APHA-AWWA-WPCF, "Standard Methods for the Examination of Water and Wastewater", 14th Edition, 1975.

52. ANSI-ASTM D346-78, "Standard Method of Sampling Coke for Analysis", Part 26, p. 213-ff, 1978.

53. U.S. EPA, "Test Methods for Evaluating Solid Waste. Physical/Chemical Methods", Report No. SW-846, 1980.

54. Blake, D.E., "Source Assessment Sampling System: Design and Development", EPA-600/7-78-018, February 1978.

55. Hamersma, J.W., S.L. Reynolds, and R.F. Maddalone, "IERL-RTP Procedures Manual: Level 1 Environmental Assessment", EPA-600/2-76-160a, June 1976.

56. Lentzen, D.E., D.E. Waggoner, E.D. Estes, and W.F. Gutknecht, "IERL-RTP Procedures Manual (Second Edition), EPA-600/7-78-201, January 1979.

57. Guilford, N.G.H. and R.J. Brandon, "Pilot Scale Evaluation of the Destruction of Waste Polychlorinated Biphenyls by Incineration", Ontario Research Foundation, Mississauga, Ontario, Canada, August 28, 1978.

58. Guilford, N.G.H. and G. Rosenblatt, "Polychlorinated Biphenyl Source Testing Survey, Ontario Region", MS Report No. OR-9, September 1977.

59. Komaniya, K. and S. Morisaki, "Incineration of Polychlorinated Biphenyls with Oxygen Burner", Environmental Science & Technology. 12 (10), 1205-1208, (1978).

60. Beard, J.H., III, and J. Schaum, "Sampling Methods and Analytical Procedures Manual for PCB Disposal: Interim Report", U.S. EPA, Office of Solid Waste, February 1978.

61. Adams, J., K. Menzies, and P. Levins, "Selection and Evaluation of Sorbent Resins for the Collection of Organic Compounds", EPA-600/7-77-044, April 1977.

62. Gallant, R.F., J.W. King, P.L. Levins, and J.F. Piecewicz, "Characterization of Sorbent Resins for Use in Environmental Sampling", EPA-600/7-78-054, March 1978.

63. Piecewicz, J.F., J.C. Harris, and P.L. Levins, "Further Characterization of Sorbents for Environmental Sampling", EPA-600/7-79-216, September 1979.

64. Neher, M.B., P.W. Jones, and P.J. Perry, "Performance Evaluation of a Solid Sorbent Hydrocarbon Sampler", Report to Electric Power Research Institute, No. EA-959, January 1979.

65. Stratton, C.L., S.A. Whitlock, and J.M. Allen, "A Method for the Sampling and Analysis of Polychlorinated Biphenyls (PCBs) in Ambient Air", EPA-600/4-78-048, August 1978.

66. U.S. EPA, "Analysis of Pesticide Residues in Human and Environmental Samples", Research Triangle Park, N.C., 1974, revised.

67. Kutz, F.W. and H.S.C. Yang, "A Note on Polychlorinated Biphenyls in Air", Paper presented at the National Conference on Polychlorinated Biphenyls", November 19-21, 1975, Chicago, IL.

68. Enos, H.F., J.F. Thompson, J.B. Mann, and R.F. Moseman, "Determination of Pesticide Residues in Air", Paper 22, Division of Pesticide Chemistry, 163rd National American Chemical Society Meeting, Boston, MA, April 1972.

69. Staiff, D.C., G.E. Quinby, D.L. Spencer, and H.C. Carr, Jr., Bull. Environ. Contam. Toxicol., 12,455 (1974).

70. Stanley, C.W., J.E. Barney, M.R. Helton, and A.R. Yobs, "Measurement of Atmospheric Levels of Pesticides", Environ. Sci. and Technol., 5, 430 (1971).

71. Hocheiser, S., "State of the Art of Measurement Techniques for Monitoring of Polychlorinated Biphenyls in the Atmosphere", U.S. EPA, Environmental Monitoring and Support Laboratory, Research Triangle Park, N.C., 1976.

72. American National Standards Institute, "Guideline for Handling and Disposal of Capacitor- and Transformer-Grade Askarels", ANSI C107.1-1974, New York, 1974.

73. American Industrial Hygiene Association, "Chlorodiphenyls", Hygiene Guide Series, February-June 1965.

74. Compton, B. and J. Bjorkland, "Design of a High Volume Sampler for Airborne Pesticide Collection", Paper 21, Division of Pesticide Chemistry, 163rd National American Chemical Society Meeting, Boston, MA, April 1972.

75. Harvey, G.R., W.G. Steinhauer, and J.M. Teal, "Polychlorinated Biphenyls in North Atlantic Ocean Water", Science, 80, 643 (1973).

76. Harvey, G.R. and W.G. Steinauer, "Atmospheric Transport of Polychlorobiphenyls to the North Atlantic", Atmos. Environ., 8, 777 (1974).

77. Wakimoto, T., R. Tachikawa, T. Ogawa, and T. Watanabe, "Method for the Quantitation of Organic Chlorine Compounds in Air", Japan Analyst, 23,790 (1974).

78. Seiber, J.N., J.E. Woodrow, T.M. Shofik, and H.F. Enos, "Determination of Pesticides and Their Transformation Products in Air", in "Environmental Dynamics of Pesticides", pp. 17-43, Plenum Press, New York, 1975.

79. Risebrough, R.W., P. Rieche, D.G. Peakall, S.G. Herman, and M.N. Kirven, "Polychlorinated Biphenyls in the Global Ecosystem", Nature, 220,1098 (1968).

80. Tessori, J.D. and D.L. Spencer, "Air Sampling for Pesticides in the Human Environment", J. Official Analytical Chemists, 54,1376 (1971).

81. Sodergren, A., "Chlorinated Hydrocarbon Residues in Airborne Fallout", Nature, 236, 395 (1972).

82. Young, D.R., D.J. McDermott, and T.C. Heesen, "Polychlorinated Biphenyl Inputs to the Southern California Bight", Paper presented at National Conference on Polychlorinated Biphenyls, Chicago, IL. 19-21 November 1975.

83. Giam, C.S., H.S. Chun, and G.S. Neff, "Rapid and Inexpensive Method for Detection of Polychlorinated Biphenyls and Phthalates in Air", Anal. Chem., 47, 2319 (1975).

84. Burg, O.W., R.B. Caton, R.D. Smillie, and R.D. Stevens, "An Ambient Air Survey for Polychlorinated Biphenyls in Ontario", Paper presented at the 70th Annual Meeting of the Air Pollution Control Association, 20-24 June 1977.

85. Bidelman, T.F. and C.E. Olney, "High Volume Collection of Atmospheric Polychlorinated Biphenyls", Bull. Environ. Contam. Toxicol., 2, 5 (1974).

86. Bidelman, T.F. and C.E. Olney, "Chlorinated Hydrocarbons in the Sargasso Sea Atmosphere and Surface Water", Science, 183, 516 (1974).

87. Rhoades, J.W., D.E. Johnson, and R.G. Lewis, "Evaluation of Collection Media for Measurement of Pesticides and Polychlorinated Biphenyls in Ambient Air", 173rd National Meeting, American Chemical Society, New Orleans, Paper No. 77, March 25, 1977.

88. Rice, C.P., C.E. Olney, and T.F. Bidelman, "Use of Polyurethane Foam to Collect Trace Amounts of Chlorinated Hydrocarbons and Other Organics From Air", Paper presented at World Health Organization Meeting, Gothenburg, Sweden, October 1976.

89. Lewis, R.G., A.R. Brown, and M.D. Jackson, "Evaluation of Polyurethane Foam for Sampling Pesticides, Polychlorinated Biphenyls, and Polychlorinated Naphthalenes in Ambient Air", Anal. Chem. 49, 1668 (1977).

90. MacLeod, K.E., "Sources of Emissions of Polychlorinated Biphenyls into the Ambient Atmosphere and Indoor Air", EPA-600/4-79-022, March 1979.

91. Young, A.L., J.A. Calcagni, C.E. Thalken, and J.W. Tremblay, "The Toxicology, Environmental Fate, and Human Risk of Herbicide Orange and Its Associated Dioxin", Report by U.S. Air Force Occupational and Environmental Health Laboratory, Brooks A.F.B., TX, No. OEHL TR-78-92, October 1978.

92. Hutzinger, O., S. Safe, and V. Zitko, "The Chemistry of PCBs", CRC Press, Cleveland, Ohio, 1974.

93. Armour, J.A., "Quantitative Perchlorination of Polychlorinated Biphenyls as a Method for Confirming Residue Measurement and Identification", J. Official Analytical Chemists, 56, 987 (1972).

94. Haile, C., "Interlaboratory Verification Analysis", Midwest Research Institute, Final report on EPA Contract No. 68-02-1399, December 1976.

95. Webb, R.G. and A.C. McCall, "Quantitative PCB Standards for Electron Capture Gas Chromatography", J. Chromatog. Sci., 11, 366 (1973).

96. Eichelberger, J.W., L.E. Harris, and W.L. Budde, "Analysis of the Polychlorinated Biphenyl Problem. Application of Gas Chromatography-Mass Spectrometry With Computer Controlled Repetitive Data Acquisition From Selected Specific Ions", Anal. Chem., 46, 227 (1974).

97. Levins, P.L., C.E. Rechsteiner, and J.L. Stauffer, "Measurement of PCB Emissions from Combustion Sources", EPA-600/7-79-047, February 1979.

98. Veith, G.D., "Baseline Concentrations of Polychlorinated Biphenyls and DDT in Lake Michigan Fish", Pesticide Monit. J., 9, 21 (1975).

99. Burg, O.W., R.B. Caton, R.D. Smillie, and R.D. Stevens, "An Ambient Air Survey for Polychlorinated Biphenyls in Ontario", Paper presented at the 70th Annual Meeting of the Air Pollution Control Association, 20-24 June 1977.

100. U.S. EPA, "Handbook. Continuous Air Pollution Source Monitoring Systems", EPA-625/6-79-005, June 1979.

101. U.S. EPA, "Guideline for Development of a Quality Assurance Program: Volume XV - Determination of Sulfur Dioxide Emissions from Stationary Sources by Continuous Monitors", EPA-650/4-74-005-O, March 1976.

102. Lustenhouwer, J.A., K. Olie, and D. Hutzinger. Chlorinated Dibenzo-p-Dioxins and Related Compounds in Incinerator Effluents: A review of Measurements and Mechanisms of Formation. Chemosphere, 9, 501-522 (1980)

103. Duvall, D.S. and W.A. Rubey, "Laboratory Evaluation of High Temperature Destruction of Polychlorinated Biphenyls", EPA-600/2-77-228, December 1977.

104. Duvall, D.S., W.A. Rubey, and J.A. Mescher, "High Temperature Decomposition of Organic Hazardous Waste", in "Treatment of Hazardous Waste. Proceedings of the Sixth Annual Symposium", D. Shultz, Ed., EPA-600/9-80-011, March 1980.

105. Buser, H.R., "Formation of Polychlorinated Dibenzofurans (PCDFs) and Dibenzo-p-Dioxins (PCDDs) From the Pyrolysis of Chlorobenzenes", Chemosphere, 6, 415 (1979).

106. Morita, M., J. Nakagawa, and C. Rappe, "Polychlorinated Dibenzofuran (PCDF) Formation from PCB Mixture by Heat and Oxygen", Bull. Environ. Contam. Toxicol., 19, 665 (1978).

107. Buser, H.R., H.P. Bosshardt, and C. Rappe, "Formation of Polychlorinated Dibenzofurans (PCDFs) from the Pyrolysis of PCBs", Chemosphere, 1, 109 (1978).

108. Buser, H.R. and C. Rappe, "Formation of Polychlorinated Dibenzofurans (PCDFs) from the Pyrolysis of Individual PCB Isomers", Chemosphere, 3, 157 (1979).

109. Pauling, L., "The Nature of the Chemical Bond and the Structure of Molecules and Crystals", Third Ed., Cornell University Press, New York, 1960.

110. Vick, R.D., C.A. Junk, M.J. Avery, J.J. Richard, and H.J. Svec, "Organic Emissions from Combustion of Combination Coal/Refuse to Produce Electricity", Chemosphere, 11, 893 (1978).

111. Eiceman, G.A., R.E. Clement, and F.W. Karasek, "Analysis of Fly Ash From Municipal Incinerators for Trace Organic Compounds", Anal. Chem., 51, 2343 (1979).

112. Olie, K., P.L. Vermeulen, and O. Hutziner, "Chlorodibenzo-p-dioxins and Chlorodibenzofurans are Trace Components of Fly Ash and Flue Gas of Some Municipal Incinerators in the Netherlands", Chemosphere, 8, 455 (1977).

113. Buser, H.R., H. Bosshardt, and C. Rappe, "Identification of Polychlorinated Dibenzo-p-dioxin Isomers Found in Fly Ash", Chemosphere, 2, 165 (1978).

114. Rappe, C. and H.R. Buser, "Formation and Degradation of Polychlorinated Dibenzo-p-dioxins (PCDDs) and Dibenzofurans (PCDFs) by Thermal Processes", Paper presented at 178th National American Chemical Society Meeting, Washington, D.C., September 9-14, 1979.

115. Carnes, R.A., J.U. Doerger, and H.L. Sparks, "Chlorinated Biphenyls in Solid Waste and Solid-Waste-Related Materials", Arch. Environ. Contam. Toxicol., 1(1), 27 (1973).

116. Manson, L. and S. Unger, "Hazardous Material Incinerator Design Criteria", EPA-600/2-79-198, October 1979.

117. Wilkinson, R.R., G.L. Kelso, and F.C. Hoskins, "State-of-the-Art Report, Pesticide Disposal Research", EPA-600/2-78-183, September 1978.

118. Riley, B.T., "Summation of Conditions and Investigations for the Complete Combustion of Organic Pesticides", EPA-600/2-75-044, October 1975.

119. Shih, C.C., R.F. Tobias, J.F. Clausen, and R.J. Johnson, "Thermal Degradation of Military Standard Pesticide Formulations", for U.S. Army Medical Research and Development Command, TRW Report No. 24768-6019-RU-00, March 1975.

120. American Council of Governmental Industrial Hygienists", TLVs Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1979", 1979.

121. Electric Power Research Institute, "Disposal of Polychlorinated Biphenyls (PCBs) and PCB-Contaminated Materials. Volume 2: Suggested Procedures for Development of PCB Spill Prevention Control and Countermeasure Plans", EPRI FP-1207, Vol. 2, October 1979.

122. Electric Power Research Institute, "Disposal of Polychlorinated Biphenyls (PCBs) and PCB-Contaminated Materials. Volume 3: Example Preparation of a Utility PCB Spill Prevention Control and Countermeasure Plan", EPRI FP-1207, Vol. 3, October 1979.

123. Perry, J.H., "Chemical Engineer's Handbook", 5th Ed., McGraw-Hill, New York, 1973.

124. Fabian, H.W., P. Reher, M. Scheren, "How Bayer Incinerates Waste", Hydrocarbon Processing, p. 183-ff, April 1979.

125. U.S. EPA, "Process Design Manual for Sludge Treatment and Disposal", EPA-625/1-74-006, October 1974.

126. Sherwood, T.K. and R.L. Pigford, "Absorption and Extraction", 2nd Ed., McGraw-Hill, New York, 1952.

127. Hanf, E.W. and J.W. MacDonald, "Economic Evaluation of Wet Scrubbers". Chemical Engineering Progress, 71 (83), 48 (1975).

128. Zenz, F.A., "Designing Gas Absorption Towers", Chemical Engineering, 79 (25), 120 (1972).

129. Calvert, S., J. Goldschmid, D. Leith, and D. Mehta. "Wet Scrubber System Study: Volume I - Scrubber Handbook", EPA-R2-72-118a, August 1972.

130. Hesketh, H.E., "Fine Particle Collection Efficiency Related to Pressure Drop, Scrubbant, and Particle Properties and Contact Mechanism", Journal of the Air Pollution Control Association, 24 (10): 939 (1974).

131. Santoro, M.A., R.E. Edwards, and C.R. Lewis, "Materials and Construction Features That Contribube to Reliability of Air Pollution Control Equipment of an Industrial Incinerator", 3M Company, 6 pp.

132. Kerchner, R.W., "Corrosion of Pollution Control Equipment", Chemical Engineering Progress, 71 (3), 58 (1975).

133. Calvert, S., "How to Choose a Particulate Scrubber", Chemical Engineering, pp. 54-68, August 24, 1977.

134. Marchello, J.M., "Gas Cleaning for Air Quality Control", Marcel Dekker, New York, 1975.

135. Paige, S.F., L.B. Baboolal, H.J. Fisher, K.H. Scheyer, A.M. Shaug, R.L. Tan, and C.F. Thorne, "Environmental Assessment: At-Sea and Land-Based Incineration of Organochlorine Wastes", EPA-600/2-78-087, April 1978.

136. Kutz, F.W. and S.C. Strassman, "Residues of Polychlorinated Biphenyls in the General Population of the United States", Paper 139 in National Conference Polychlorinated Biphenyls, November 19-21, 1975, Chicago, EPA 560/75-004.

137. U.S. EPA, "Polychlorinated Biphenyls - Ambient Water Quality Criteria", Criteria and Standards Division, Office of Water Planning and Standards, U.S. Environmental Protection Agency, Washington, D.C., NTIS # PB 296 803, 1978.

138. Huibregtse, K.R., R.C. Scholz, R.E. Wullschleger, J.H. Moser, E.R. Bollinger, and C.A. Hansen, "Manual for the Control of Hazardous Material Spills, Volume 1. Spill Assessment and Water Treatment Techniques", EPA-600/2-77-277, November 1977.

139. Personal communication from Philip C. Schwindt, U.S. EPA, Region VI, October 8, 1980.

140. Dixon, W.J. and F.J. Massey, Jr., "Introduction to Statistical Analysis", 3rd Ed., McGraw-Hill, New York, 1969.

141. Chemical Rubber Company, "Handbook of Tables for Probability and Statistics", 2nd Ed., Chemical Rubber Company, Cleveland, 1968.

APPENDIX A

THE PCB REGULATIONS

federal register

Thursday
May 31, 1979

Part VI

Environmental Protection Agency

Polychlorinated Biphenyls; Criteria Modification; Hearings

ENVIRONMENTAL PROTECTION AGENCY

40 CFR Part 761

[FRL 1075-2]

Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions

AGENCY: Environmental Protection Agency.

ACTION: Final rule.

SUMMARY: This final rule implements provisions of the toxic Substances Control Act (TSCA) prohibiting the manufacture, processing, distribution in commerce, and use of polychlorinated biphenyls (PCBs). Specifically, this rule:

(1) Prohibits all manufacturing of PCBs after July 2, 1979 unless specifically exempted by the Environmental Protection Agency (EPA);

(2) Prohibits the processing, distribution in commerce, and use of PCBs except in a totally enclosed manner after July 2, 1979;

(3) Authorizes certain processing, distribution in commerce, and use of PCBs in a non-totally enclosed manner (which would otherwise be subject to the prohibition described above);

(4) Prohibits all processing and distribution in commerce of PCBs after July 1, 1979, unless specifically exempted by EPA.

EFFECTIVE DATE: July 2, 1979. The disposal and marking rule (43 FR 7150, February 17, 1978, as amended by 43 FR 33918 August 2, 1978) shall remain in effect until the rule promulgated today becomes effective.

FOR FURTHER INFORMATION CONTACT: For information concerning this rule and for copies of this rule contact: John Ritch, Jr., Director, Office of Industry Assistance, Office of Toxic Substances (TS-799), Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20460. Call the toll-free number (800)-424-9065, or in Washington, D.C. call 554-1404.

The support documentation for this rule can also be obtained through the above-mentioned address. The support documentation consists of two parts and are entitled *Support Document/Voluntary Environmental Impact Statement* and *PCB Manufacturing, Processing, Distribution in Commerce Ban Regulation: Economic Impact Analysis.* (This *Economic Impact Analysis* is hereinafter referred to as the Versar Report). These two documents have been reproduced and bound into one publication.

SUPPLEMENTARY INFORMATION:

Format of Rule

In order to clarify the relationship between the PCB Disposal and Marking Rule and the PCB Ban Rule, all of Part 761 is printed in this notice in a fully integrated form. This notice incorporates the Disposal and Marking Rule (43 FR 7150, February 17, 1978) for PCBs and the technical amendments (43 FR 33918, August 2, 1978) to that Rule into one regulation. Therefore, this notice supercedes the previous notices on July 2, 1979.

Background

Section 6(e) of TSCA requires EPA to control the manufacture, processing, distribution in commerce, use, disposal, and marking of polychlorinated biphenyls (PCBs). On February 17, 1978, EPA published the PCB Disposal and Marking Rule in the **Federal Register** (43 FR 7150). Clarifying amendments to this rule were published on August 2, 1978 (43 FR 33918).

Section 6(e)(2) provides that no person may manufacture, process, distribute in commerce, or use any PCB in a manner other than in a "totally enclosed manner" after January 1, 1978, except to the extent EPA authorizes activities in a non-totally enclosed manner. On December 30, 1977, EPA published a notice (42 FR 65264) stating that implementation of the January 1, 1978 ban would be postponed until 30 days after promulgation of this rule.

Section 6(e)(3) provides that no person may manufacture any PCB after January 1, 1979, or process or distribute in commerce any PCB after July 1, 1979, except to the extent that EPA specifically exempts such activities. Implementation of the January 1, 1979 ban was postponed until 30 days after the promulgation of the rule published today (See 44 FR 108, January 2, 1979).

Section 6(e)(3)(B) provides that persons may petition the Administrator for exemptions from the prohibition of the manufacture of PCBs, which goes into effect July 2, 1979 or from the prohibition of processing and distribution in commerce, which goes into effect July 1, 1979. Interim rules establishing procedures for submitting petitions for exemptions from the manufacturing prohibition were published November 1, 1978 (43 FR 50905). More than 70 petitions for exemptions have been received. On January 2, 1979, EPA announced (44 FR 108) that it would not enforce the PCB manufacturing and importation ban of section 6(e)(3)(A) against persons who had submitted petitions until EPA has acted on their exemption petition. This nonenforcement policy applies solely to activities that are properly subject to a pending PCB manufacturing or importation exemption petition.

Elsewhere in today's **Federal Register**, EPA has published a Notice of Proposed Rulemaking that identifies each petition received for exemptions from the manufacturing prohibition and, in most cases, the action that EPA proposes to take on individual petitions. Rules establishing procedures for submitting petitions for exemptions from the processing and distribution in commerce prohibitions will be published in the near future.

Authority to grant or deny petitions for exemptions from the PCB processing and distribution in commerce bans under section 6(e)(3)(B) of TSCA, as well as the authority to revise the procedural rules for PCB exemptions and to grant further PCB authorizations and to amend or modify this regulation is delegated to the Assistant Administrator for Toxic Substances. This authority was previously delegated to the Assistant Administrator for Toxic Substances for the PCB manufacturing exemptions (see 43 FR 50905).

This final rule implementing sections 6(e) (2) and (3) of TSCA was proposed June 7, 1978 (43 FR 24802). Ten days of public hearings were held in Washington, D.C., from August 21 to September 1. Over 50 oral presentations were made and two hearing participants conducted cross-examination on September 28, 1978. On September 22, 1978 (43 FR 43048), EPA published a notice of the opportunity for cross-examination and extended the reply comment period to October 10, 1978. EPA received over 200 comments on the proposed rule.

EPA has produced, as part of the rulemaking process for PCBs, two support documents. The first support document which was entitled *Support Document/Voluntary Draft Environmental Impact Statement*, was made available at the time the proposed rule was published and discussed the health and environmental effects of PCBs, the substitutes for PCBs, and the regulatory alternatives EPA considered in developing the proposed PCB Ban Rule. The second support document entitled *Support Document/Voluntary Environmental Impact Statement* was prepared along with the final PCB Rule and Preamble. This particular document contains updated versions of the health and environmental effects and PCB substitutes sections, and addresses the major comments that were made on the proposed rule during the comment period. In many cases these comments led to changes to the proposed PCB Ban Rule. There are also two versions of the economic impact analysis that have been prepared by Versar, Inc. The first Versar Report was made available at the time of the proposed PCB Ban Rule. The second, or final Versar Report, has been incorporated into the final Support Document. Copies of the final Support Document can be obtained from the Industry Assistance Office identified above.

Table 1—Contents of Preamble

I. Summary of the Rule's Organization
II. Changes in Major Definitions
  A. "PCB" and "PCB Items"
  B. Regulation of PCBs at the 50 ppm Concentration Level
  C. Classification of Transformers Under This Rule
1. PCB Transformers
2. PCB-Contaminated Transformers
3. Non-PCB Transformers
4. Discussion of Transformer Categories
a. Determining Appropriate Categories
b. Significance of Transformer Categories
  D. Totally Enclosed Manner and Significant Exposure
  E. Sale for Purposes Other Than Resale
  F. Other Definitions.
III. Changes in Subpart B: Disposal of PCBs and PCB Items
  A. Mineral Oil Dielectric Fluid with 50 to 500 ppm PCB
1. High Efficiency Boilers
2. Conditions for Boilers
3. Other Disposal Alternatives
  B. Other Liquid Wastes with 50 to 500 ppm PCB
  C. Disposal of 50 to 500 ppm PCB Liquids in Chemical Waste Landfills
  D. Disposal of Non-Liquid PCBs in Chemical Waste Landfills
  E. Batch Testing of Mineral Oil Dielectric Fluid
  F. Other Changes in the Disposal Requirements
IV. Changes in Subpart C: Marking of PCBs and PCB Items
V. Changes in Subpart E: Annexes
  A. Annex I: Incineration
  B. Annex II: Chemical Waste Landfills
  C. Annex III: Storage
1. Container Specifications
2. Bulk Storage
3. Spill Prevention Procedures
4. Flood Protection
5. Temporary Storage
a. Revisions
b. Action on Petitions to Amend Rule on Temporary Storage Requirements
  D. Annex IV: Decontamination
  E. Annex VI: Records and Monitoring
VI. Subpart D: Manufacturing, Processing, Distribution in Commerce, and Use Bans
  A. Prohibitions
1. Waste Oil Bans
  B. Changes in § 761.30: Prohibitions
1. Change in Scope of Manufacturing Ban
a. "Manufacturing" versus "Processing" of PCB Items
b. Manufacture and Import of PCB Items
2. Import and Export of PCBs and PCB Items for Disposal
  C. Other Issues
1. PCB Impurities and Byproducts
2. Disposal of Small PCB Capacitors
3. State Preemptions
VII. Relationship of § 6(e)(2) to § 6(e)(3) in TSCA
VIII. Authorizations and Exemptions
  A. Explanation of Authorizations and Exemptions
1. Manufacturing Exemptions
2. Processing and Distribution in Commerce Exemptions
  B. General Changes in § 761.31: Authorizations
1. Reporting and Recordkeeping Requirements
2. Length of Use Authorizations
3. Changes in § 761.46: Annex VII
IX. Specific Authorizations
  A. Servicing Transformers (Other Than Railroad Transformers)
1. General Discussion of Transformer Servicing
2. PCB Transformers
3. PCB-Contaminated Transformers
4. Rebuilding PCB Transformers
5. Contents of Authorization
  B. Use and Servicing of Railroad Transformers
  C. Use and Servicing of Mining Equipment
  D. Use in Heat Transfer Systems
  E. Use in Hydraulic Systems
  F. Use in Carbonless Copy Paper
  G. Pigments
  H. Use and Servicing of Electromagnets
  I. Use in Natural Gas Pipeline Compressors
  J. Use of Small Quantities for Research and Development
  K. Use in Microscopy
X. PCB Activities Not Authorized by this Rule
  A. Manufacture of PCB Capacitors
  B. Manufacture of PCB Transformers
  C. Other PCB Activities
XI. Manufacturing, Processing, and Distribution in Commerce of PCBs for Export
XII. Test Procedures for PCB
XIII. Compliance and Enforcement
XIV. Relationship of PCB Disposal Under TSCA to Hazardous Waste Disposal Under RCRA
XV. Summary of Economic Consequences

I. Summary of the Rule's Organization

Subpart A (§§ 761.1 and 761.2) of this rule contains general provisions applicable to all other Subparts. Section 761.1 states the applicability of the provisions of the rule. Section 761.2 contains definitions of terms used in the rule. Subparts B (§ 761.10) and C (§ 761.20) contain disposal and marking requirements. Subpart D (§§ 761.30 and 761.31) concerns the manufacturing, processing, distribution in commerce, and use of PCBs. Section 761.30 contains prohibitions on activities while § 761.31 sets out authorizations under TSCA section 6(e)(2)(B). Subpart E contains Annexes to the rule concerning incineration of PCBs, chemical waste landfills, storage for disposal, decontamination, marking, and records and monitoring.

The preamble to this rule primarily describes changes from the proposal. Except to the extent that it is inconsistent with this final rule preamble, the preamble to the proposed rule (43 FR 24802, June 7, 1978) is incorporated by reference into this document and should be consulted for additional information (see 43 FR 24802–24812, June 7, 1978). The contents of this preamble are summarized in Table 1. The amount of PCBs used in different PCB activities and the impact this rule will have on these PCBs is summarized in Table 2.

Table 2.—Quantities of PCB's Used in PCB Activities[9]

Activity	Pounds used	Pounds regulated	Pounds prohibited
PCB Transformers	295,000,000	295,000,000	0
PCB-Contaminated Trans	~400,000	~400,000	0
Railroad Trans	5,000,000	5,000,000	5,000,000[1]
Mining Motors	34,000	34,000	34,000[2]
Hydraulic Systems	750–3500	750–3500	750,3500[3]
Heat Transfer	40,000–180,000	40,000–180,000	40,000–180,000[2]
Carbonless Copy Paper	(7)	(7)	0.
Pigments	5,700/yr	5,700/yr	5,700/yr[4]
Electromagnets	20,000–30,000	20,000–30,000	0.
Compressors	Small	All	All[5]
Small Quantity R&D	Very small	All	(6)
Microscopy	Very small	All	(6)
PCB Capacitors/PCB Equip	460,000,000	282,500,000	
Process Contamination[10]	100,000–500,000/yr	100,000–500,000/yr	100,000–5000,000/yr[4]
Dust Control, Sealants, Coatings from Waste Oil	32,000/yr	32,000/yr	32,000/yr
	~750,860,000	~583,300,000[8]	~5,430,000

[1] Over a five year period.

[2] Over a three year period.

[3] Draining and refilling required until at 50 ppm.

[4] Subject to exemption.

[5] Use authorized but other activities need exemption.

[6] In one year.

[7] Amount of PCB carbonless copy paper inventories unknown. Use is authorized indefinitely.

[8] The difference between this value and the one in the column to the left is the PCB in small capacitors, which are uncontrolled.

[9] Data derived from Versar report.

[10] Data estimated from petitions for exemptions from the manufacturing ban.

Reproduced from best available copy.

II. Changes in Major Definitions

A. *"PCBs" and "PCB Items"*

This final rule changes the definition of "PCB" from that contained in the proposal in two significant respects. In the proposed rule, § 761.2(q) defined "PCB" and "PCBs" to include PCB Chemical Substances, PCB Mixtures, PCB Articles, PCB Equipment, PCB Containers, and PCB Sealants, Coatings, and Dust Control Agents. Section 761.2(s) of the final rule defines "PCB" and "PCBs" to mean any chemical substance or combination of substances that is limited to the biphenyl molecule that has been chlorinated to varying degrees. This definition is essentially what the proposal defined as "PCB Chemical Substance". This term and the term "PCB Mixture" have been deleted from the rule. Because some provisions in the rule apply to concentrations of PCBs below 50 ppm (e.g., the ban on the use of PCBs as sealants, coatings, and dust control agents), the applicability section (§ 761.1(b)) explains that wherever the term "PCB" or "PCBs" is used in this rule, it means PCBs at a concentration of 50 ppm or greater unless otherwise specified.

The second principal change is the addition of a new term, "PCB Item", defined as "any PCB as it is a part of, or contained in, any 'PCB Article', 'PCB Article Container', 'PCB Containers' or 'PCB Equipment', at a concentration of 50 ppm or greater" (see § 761.2(x)). This change significantly affects the scope of the manufacturing ban. (See preamble section VI.B.1. below.)

B. Regulation of PCBs at the 50 ppm Concentration Level

To implement this rule in a practical manner, it is essential that EPA adopt a regulatory cut-off point based upon the concentration of PCBs. PCBs are widely dispersed in the environment and are found worldwide at low concentration. This wide dispersion has occurred because hundreds of millions of pounds of PCBs have been used in the past with little or no attempt to control their use or disposal. Because PCBs are now so pervasive, the effect of not having a cut-off concentration would be to extend the prohibitions and other requirements of section 6(e) of TSCA to almost all human activity. Many foods, such as fish and milk, as well as the human body often contain detectable concentrations of PCBs.

The final rule applies to any substance, mixture, or item with 50 ppm or greater PCB. This 50 ppm cut-off was proposed as a change from the Disposal and Marking Rule (43 FR 7150, February 17, 1978), which specified a 500 ppm cut-off. (See definition of "PCB Mixture" in that rule (§ 761.2(w), 43 FR 7157).)

Where to set the cut-off point for the PCB rule has been an issue throughout the development of both the Disposal and Marking Rule and the Ban Rule. The preamble to the proposed Disposal and Marking Rule (see 42 FR 26564, May 24, 1977) first discussed the issue under the heading "PCB Mixtures, Waste Materials, and Sludges". The preamble to the final Disposal and Marking Rule discussed the issue further under the heading "Changes in § 761.2 Definitions" (see 43 FR 7151, February 17, 1978). This discussion stated that EPA was seriously considering lowering the PCB concentration in the definition of "PCB Mixture" from 500 ppm to possibly 50 ppm. The preamble to the proposed Ban Rule emphasized that EPA must select a cut-off point that it can reasonably administer in order to attain the objectives of §6(e) of TSCA (see 43 FR 24804, June 7, 1978).

Before selecting 50 ppm PCB as the cut-off point, EPA considered several other options, including retaining the 500 ppm PCB cut-off originally specified in the Disposal and Marking Rule, and lowering the cut-off concentration to 10 ppm or even 1 ppm. The 500 ppm PCB option was favored by affected industries because it would reduce the costs of complying with the rule, but no evidence was presented that indicated that industry is technologically or economically unable to comply with the more stringent standard. In fact, in this final rule, EPA is easing the economic burden of complying with the more stringent standard by allowing alternative disposal methods for certain wastes containing between 50 ppm and 500 ppm PCB.

Lowering the PCB cut-off point from 500 ppm to 50 ppm will result in substantially increased health and environmental protection. Using data developed by Versar, Inc. of Springfield, Virginia, EPA estimates that approximately one million additional pounds of existing PCBs will be controlled by lowering the cut-off to 50 ppm. In addition, from 100,000 to 500,000 pounds per year (estimated from manufacturing exemption petitions) of new PCBs will be controlled. Because Congress intended that EPA address the problem of contamination of the environment by PCBs to the greatest extent possible, EPA believes that regulating this substantial additional amount of PCBs is justified.

Lowering the cut-off concentration to 10 ppm PCB would provide an additional degree of environmental protection but would have a grossly disproportionate effect on the economic impact and would have a serious technological impact on the organic chemicals industry. Although firm data are not available, investigations have indicated that a number of chlorinated organic chemicals are produced with PCB concentrations of 10 ppm to 30 ppm and that it may be very difficult technically to alter the production processes to produce lower levels of PCBs or eliminate them. In addition, a 10 ppm concentration cut-off would also substantially increase the scope of the disposal requirements, especially for soils, debris, and solvents contaminated with low concentrations of PCBs. Those wastes would be added to the total quantity of waste at these PCB disposal sites. Since PCB disposal site capacity is limited, these additional wastes would add to the volume of wastes stored at PCB storage facilities. Illegal disposal of PCB wastes and inadvertant releases of PCBs into the environment are more likely to occur when disposal capacity is not readily available.

EPA recognizes that increased environmental benefits could result if additional PCBs were destroyed or controlled by regulating PCBs at very low concentrations. These potential benefits would be negated, however, if high-concentration PCB wastes are not properly disposed of because the limited disposal capacity for PCB wastes and EPA's surveillance and enforcement efforts are diverted to low concentration wastes. In addition, other authorities administered by EPA, such as the Clean Water Act (CWA) and the Marine Protection, Research, and Sanctuaries Act, can be used to regulate low concentrations of PCBs. EPA has the ability to control environmental releases of certain low concentration PCBs through the National Pollutant Discharge Elimination System (section 402 of CWA), through dredging permits (§ 404 of CWA) and through toxic effluent standards and prohibitions (section 307(a) of CWA).

The arguments against a cut-off of 10 ppm are pertinent to a cut-off of 1 ppm to an even greater extent. Foods, such as milk and fish, and even the human body itself often contain PCBs at this low concentration. For these reasons, EPA also decided not to adopt a cut-off of 1 ppm.

After reviewing the public comments, informal hearing testimony, and other information in the rulemaking record and then evaluating the available options, EPA concludes that retaining the PCB cut-off limit at 50 ppm provides adequate protection for human health and the environment while defining a program that EPA can effectively implement.

The major exception in the rule to the 50 ppm limit is the prohibition of the use of waste oil as a sealant, coating, or dust control agent if the waste oil contains any detectable concentration of PCB. This prohibition is necessary to prevent the use of PCB-contaminated materials in ways that result in direct and widespread environmental contamination. Road oiling, other dust control, pipe coating, and spraying of vegetation permit substantial direct entry of PCBs into the air and waterways and may introduce PCBs into the food chain.

C. Classification of Transformers Under This Rule

This rule establishes four categories of transformers: 1) PCB Transformers; 2) PCB-Contaminated Transformers; 3) Non-PCB Transformers; and 4) Railroad Transformers. Railroad Transformers are discussed in the preamble section IX.B. The other three categories are discussed immediately below.

PCB Transformers

PCB Tranformers are transformers that contain PCBs at a concentration of 500 ppm or greater. This category includes transformers that were designed to use concentrated PCBs (40 percent or greater PCBs) as a dielectric fluid, as well as transformers that were not designed to use concentrated PCBs but contain 500 ppm or greater PCB. The higher concentration of PCB could result from an unusual contamination incident at the manufacturing facility, from careless servicing operations, or from deliberate attempts to use concentrated PCBs as a dielectric fluid. The selection of 500 ppm as the lower limit defining a PCB Transformer is directly related to the selection of limits for defining PCB-Contaminated Transformers. This is discussed in section C.2 immediately below.

A transformer must be assumed to be a PCB Transformer if any one of the following conditions exist: (1) the nameplate indicates that the transformer contains PCB dielectric fluid; (2) the owner or operator has any reason to believe that the transformer contains PCB dielectric fluid; or (3) the transformer's dielectric fluid has been tested and found to contain 500 ppm or greater PCB. If a transformer does not have a nameplate or if there is no information available to indicate the type of dielectric fluid in it, the transformer must be assumed to be a PCB Transformer unless it is tested and found to contain less than 500 ppm PCB. This category of transformers is defined in the rule in § 761.2(y).

2. PCB-Contaminated Transformers

PCB-Contaminated Transformers are transformers that contain between 50 ppm and 500 ppm PCB. This category includes transformers that were designed to use PCB-free mineral oil dielectric fluids but now contain between 50 ppm and 500 ppm of PCBs because of contamination that occurred in manufacturing or servicing operations. Available data indicate that as many as 38 percent of the 35,000,000 mineral oil transformers contain between 50 and 500 ppm PCBs but that PCB concentrations above 500 ppm in such transformers are rare. Based on these data, EPA is specifying 50 to 500 ppm as the range of PCB concentration defining PCB-Contaminated Transformers. The data also support the requirement that all mineral oil transformers must be assumed to be PCB-Contaminated Transformers unless tested and found not to contain between 50 and 500 ppm PCB.

The upper limit of 500 ppm is a practical cut-off because it includes virtually all mineral oil transformers that are substantially contaminated with PCBs and it coincides with the February 17, 1978 PCB Disposal and Marking Rule limit for defining a "PCB Transformer". Because most of the requirements of this rule apply only to PCB concentrations of 50 ppm or greater (see preamble section II.B above), 50 ppm is the logical choice for a lower limit for PCB-Contaminated Transformers.

As discussed in section C.4 below, PCB Transformers may be converted to PCB-Contaminated Transformers by draining and replacing the dielectric fluid as long as the replacement fluid is between 50 and 500 ppm PCBs after three months of in-service use. The term PCB-Contaminated Transformer is defined in § 761.2(z).

3. Non-PCB Transformers

Non-PCB Transformers are transformers that contain less than 50 ppm PCB. No transformer may ever be considered to be a Non-PCB Transformer unless its dielectric fluid has been tested or otherwise verified to contain less than 50 ppm PCB. A person who tests his transformers to classify them as Non-PCB Transformers should also take precautions to insure that these transformers are not later contaminated in servicing operations. Addition of PCB-contaminated fluid, for example, may result in PCB levels over 50 ppm.

Non-PCB Transformers are not specifically covered by this rule. However, it is possible that the dielectric fluid in these transformers may contain a detectable, but less than 50 ppm PCB concentration. In this case, the rule's prohibition of the use of waste oil containing any detectable PCBs as a sealant, coating, or dust control agent would be applicable when the dielectric fluid is removed from the transformer. The term Non-PCB Transformer is not defined in the rule.

4. Discussion of Transformer Categories

The owner or operator of a transformer must ascertain which of these three categories, PCB Transformer, PCB-Contaminated Transformer, or Non-PCB Transformer, is applicable. In determining this, a person must make certain assumptions, as discussed below.

a. Determining Appropriate Categories

Transformers originally designed to use concentrated PCBs usually have a nameplate indicating that they contain PCB dielectric fluid. Such transformers must be assumed to be PCB Transformers unless tested and found to contain less than 500 ppm PCB. The same assumption must also be made if there is any other reason to believe that a transformer was designed to use concentrated PCB fluid or was ever filled with such fluid. If a transformer does not have a nameplate or if there is no information available to indicate the type of dielectric fluid in it, the transformer must be assumed to be a PCB Transformer.

If the owner or user has serviced the transformer to reduce the PCB concentration below 500 ppm, he cannot simply assume that the PCB reduction process was successful. Because PCBs can continue to leach out of transformer windings after refilling with dielectric fluid containing less than 50 ppm PCB, the owner must test to determine the PCB concentration in the dielectric fluid if he wants to reclassify such a transformer. The test must be performed only after the transformer has been in use for three months or longer after the most recent servicing intended to reduce the PCB concentration. If this test shows the transformer dielectric fluid to contain between 50 ppm and 500 ppm PCB, then the transformer can be reclassified as a PCB-Contaminated Transformer. If the PCB reduction was successful enough to reduce the PCB concentration below 50 ppm, then the transformer would be a Non-PCB Transformer. Owners or operators of reclassified transformers must retain records of their tests in order to be able to demonstrate compliance with the reclassification requirements.

Because of the widespread PCB contamination of transformers that were designed to use PCB-free mineral oil dielectric fluid, all such mineral oil dielectric fluid transformers must be assumed to be PCB-Contaminated Transformers, unless reasons exist to believe that a transformer was filled with greater than 500 ppm PCB fluid (in which case the assumption is that the transformer is a PCB Transformer). The owner or operator has the option of testing the dielectric fluid to determine if the PCB concentration is below 50 ppm. This testing must be performed on the dielectric fluid that is in the transformer. If the PCB concentration in the dielectric fluid is below 50 ppm, then the transformer may be considered a Non-PCB Transformer.

If any 500 ppm or greater PCB fluids are added to a collection tank, the entire tank contents must be considered to be greater than 500 ppm PCBs and be disposed of in an incinerator that meets the requirements found in Annex I of the rule. (In other parts of this preamble this will be referred to as an Annex I incinerator.) The tank contents *cannot* be used as dielectric fluid; the tank contents *must* be disposed of. In addition, PCB-free or low concentration PCB fluids cannot be added to the tank in order to dilute the tank contents to a level below 50 ppm PCBs and avoid more stringent disposal requirements. High concentration PCBs must be disposed of in accordance with the applicable requirements even if the concentration of PCBs could be or is actually lowered by dilution. This requirement is intended to prevent the deliberate dilution of concentrated PCBs to evade the more stringent disposal requirements that apply to such liquids. In addition, to permit dilution in this way would result in greater dissemination of PCBs and, consequently, greater human and environmental exposure to PCBs. The use of collection tanks for mineral oil dielectric fluid is discussed further in preamble section III.E.

b. Significance of Transformer Categories

The three categories of transformers are subject to different disposal, rebuilding, and storage requirements under these rules. Fluids from Non-PCB Transformers (with less than 50 ppm PCBs) have one disposal restriction: they cannot be used as a sealant, coating, or dust control agent if they contain any detectable PCB. Fluids from PCB-Contaminated Transformers (with 50 ppm or 500 ppm PCBs) must be disposed of in high efficiency boilers, in approved chemical waste landfills, or in Annex I incinerators. (See section III.A below). Fluids from PCB Transformers (concentrations of 500 ppm or greater) must be disposed of only by high temperature incineration.

Other significant activities for which the categories have different requirements are servicing (including rebuilding) and disposal (of the transformer coil and casing). PCB-Contaminated Transformers are subject to no restrictions on servicing (including rebuilding) or coil and casing disposal, except that after July 1, 1979, servicing of PCB-Contaminated Transformers must be performed either by the owner or operator or by someone who has an exemption from the processing and distribution in commerce bans. The major advantage of recategorizing a PCB-Contaminated Transformer to Non-PCB Transformer is that no exemption would be needed for servicing and that simpler dielectric fluid disposal requirements would apply.

The servicing and disposal of PCB Transformers are subject to more stringent restrictions. Any servicing of PCB Transformers that requires the removal of the coil from the casing is prohibited and PCB Transformer coils and casings must be disposed of either in an Annex II chemical waste landfill or in an Annex I high temperature incinerator. Any fluid removed from a PCB Transformer being serviced must either be reused as dielectric fluid or disposed of in an Annex I incinerator. Any fluid removed from a PCB Transformer that is being disposed of must be disposed of in an Annex I incinerator. Servicing that does not require the removal of the coil can be performed, but persons who process or distribute PCBs in commerce for purposes of servicing must be granted an exemption by EPA. Consequently, recategorizing a PCB Transformer to a PCB-Contaminated Transformer by lowering the PCB concentration would permit rebuilding of the transformer, simplify future disposal, and permit salvage of the casing and coil. Rebuilding may be especially important to owners of transformers that are used in special applications or have unique design characteristics and that cannot be readily replaced in the event of a failure.

D. Totally Enclosed Manner and Significant Exposure

The definitions of these terms are basically unchanged from those contained in the proposed rule. See the preamble to the proposed rule (43 FR 24805–6, June 7, 1978) for a discussion of these terms.

E. Sale for Purposes Other Than Resale

Two modifications have been made to this definition. First, sale for purposes of research and development is not considered to be for purposes other than resale. The proposed rule excluded all activities involving small quantities of PCBs for research and development (as defined in § 761.2(ee)). The final rule includes such activities within its scope and authorizes the processing and distribution in commerce of small quantities for research and development until July 1, 1979 (after which exemptions would be required to continue these activities) and authorizes use of such quantities until July 1, 1984 (see preamble section IX.J).

The second change concerns leasing of PCB Equipment. The proposed rule would have required that PCB Equipment be leased for a minimum of one year. The final rule provides that the lease period may be for any period of time provided that the lease begins before July 1, 1979. The import and export of leased equipment will require an exemption after July 1, 1979 (see preamble section VI.B.1.b).

F. Other Definition Changes

The definitions of "Chemical Waste Landfill" (§ 761.21(f)) and "Incinerator" (§ 761.2(1)) have been modified in a minor way to reflect more closely the proposed definitions developed for these facilities under the Hazardous Waste Regulations developed pursuant to the Resource Conservation and Recovery Act (RCRA). The changes do not affect the criteria for these facilities in Annexes I and II of the PCB Disposal and Marking Rule.

Definitions for "Byproducts" (§ 761.2(c)) and "Impurity" (§ 761.2(k)) have been added. These definitions are the same as those promulgated in EPA's inventory regulation under section 8 of TSCA (42 FR 64572). (See preamble section VI.C.1.)

III. Changes in Subpart B: Disposal of PCBs and PCB Items

A. Mineral Oil Dielectric Fluid With 50 to 500 ppm PCB

The proposed rule would have changed the PCB Disposal and Marking Rule by requiring all PCBs containing 50 ppm or more PCB to be disposed of in an incinerator meeting the requirements of Annex I. This requirement would have increased the quantity of liquid to be incinerated over the next 30 to 40 years from 300 million pounds to at least 3 billion pounds, with proportional increases in costs (see the Versar Report). This increase would also have severely strained available incineration capacity. EPA was concerned about the impact of this requirement and requested comments on the use of high temperature boilers for incinerating PCB contaminated mineral oil.

1. High Efficiency Boilers

A substantial number of comments stated that power generation facilities could provide an environmentally safe alternative for burning PCB-contaminated mineral oil. EPA reviewed the comments and investigated the feasibility of permitting the use of boilers as a disposal option. After exploring this matter with combustion experts, EPA concluded that there are boilers capable of adequately incinerating PCB-contaminated mineral oil. These boilers (which can be referred to as "high efficiency boilers") include power generation boilers and industrial boilers that operate at a high combustion efficiency (99.9%), as defined by the carbon monoxide concentrations and excess oxygen percentages in the combustion emissions.

These boilers are capable of achieving a PCB destruction efficiency of 99.9% or greater. This destruction efficiency is somewhat lower than the estimated 99.9999% or greater destruction efficiency that an Annex I incinerator can achieve. However, this disposal alternative is restricted to PCB-contaminated mineral oil of low PCB concentration (50–500 ppm) and offers a substantial reduction in disposal costs (over $13 million per year). Given the 99.9% destruction efficiency for PCBs in high efficiency boilers, only 10 more pounds of PCB would enter the environment annually as compared to the amount released from high temperature incinerators under Annex I. (This estimate is derived from Versar data).

After considering these factors, EPA concluded that disposing of PCB-contaminated mineral oil containing 50 to 500 ppm PCB in high efficiency boilers does not present an unreasonable risk to human health or the environment. However, for the reasons explained in section III.B, only PCB-contaminated mineral oil will be permitted to be burned in boilers without specific approval by the appropriate EPA Regional Administrator. A discussion of the burning of other low concentration PCB wastes also is found in section III.B.

2. Conditions for Boilers

Based on the conclusions stated above, the final rule permits the burning of PCB-contaminated mineral oil with a concentration below 500 ppm in high efficiency boilers if the following conditions are met: (1) the boiler is rated at a minimum of 50 million BTU/hour; (2) the mineral oil is no more than ten percent of the total fuel feed rate; (3) the mineral oil is not added to the combustion chamber during boiler start-up or shut-down operations; (4) before commencing the burning of PCB-contaminated mineral oil, the owner or operator has conducted tests and determined that the combustion emissions contain at least three percent (3%) excess oxygen and the carbon monoxide concentration does not exceed 50 ppm for oil or gas-fired boilers or 100 ppm for coal-fired boilers; (5) the company has notified the appropriate EPA Regional Administrator at least 30 days before the company uses its high efficiency boiler for this purpose and has supplied the notice with the combustion emissions data as specified in (4) above; (6) the combustion process is monitored either continuously or, for boilers burning less than 30,000 gallons of mineral oil annually, at least once each hour that PCB-contaminated mineral oil is burned, to determine the percentage of excess oxygen and the carbon monoxide level in the combustion emission; (7) the primary fuel and mineral oil feed rates are monitored at least every 15 minutes whenever burning PCB-contaminated mineral oil; (8) the carbon monoxide and excess oxygen levels are checked at least once an hour and, if they fall below the specified levels, the flow of mineral oil to the boiler is immediately stopped; and (9) records are maintained that include the monitoring data in (6) and (7) above and the quantities of PCB-contaminated mineral oil burned each month. When burning mineral oil dielectric fluid, the boiler must operate at a level of output no less than the output at which the reported carbon monoxide and excess oxygen measurements were taken. The Regional Administrator has to be notified only before the first burning of PCB-contaminated mineral oil in the boiler. The conditions are intended to prevent the introduction of PCBs into boilers when combustion conditions are not optimum for the destruction of PCBs. The level of 30,000 gallons per year was chosen as the cut-off for continuous monitoring because, (1) EPA believes that boilers burning 30,000 gallons or more per year of PCB-contaminated mineral oil would be burning on a regular basis and therefore should continuously monitor CO and excess O_2; and (2) a boiler burning this quantity of mineral oil annually will incur more than sufficient savings over high temperature incineration or chemical waste landfill disposal costs to offset the added costs of continuous monitoring. However, a person whose boiler does not meet these requirements but who can demonstrate that the boiler will destroy PCBs as efficiently as a high efficiency boiler may seek specific approval from the appropriate EPA Regional Administrator under § 761.10(a)(2)(iv).

EPA plans to monitor the use of these boilers closely and will carefully analyze the effectiveness of this disposal option.

3. Other Disposal Alternatives

Alternatively, any PCB-contaminated mineral oil dielectric fluid (with a PCB concentration less than 500 ppm) may be disposed of either in an incinerator complying with Annex I or, under special conditions (see section III.C below), in a chemical waste landfill complying with Annex II. These landfills will provide a disposal option less costly than Annex I incineration for owners or users of PCB-contaminated mineral oil who do not have access to high efficiency boilers. EPA believes that only small quantities of dielectric fluid will be disposed of in landfills because high efficiency boilers or incinerators will be available for most of the waste fluids.

The impact on human health and the environment from disposing of these wastes in chemical waste landfills is discussed in the preamble section III.B below.

B. Other Liquid Wastes With 50 to 500 ppm PCB

To provide thermal destruction alternatives for other low concentration liquid wastes containing less than 500 ppm PCB, EPA has included in the rule a procedure that is comparable to the disposal alternatives for PCB-contaminated mineral oil. This procedure permits the disposal of these non-mineral oil fluids on a case-by-case basis in high efficiency boilers.

Such approval can be granted if: (1) the boiler is rated at a minimum of 50 million BTU/hour; (2) the PCB-contaminated waste comprises no more than ten percent (10%) of the total volume of fuel; (3) the waste will not be added to the combustion chamber during boiler start-up or shut-down operations; (4) the combustion emissions will contain at least three percent (3%) excess oxygen and the carbon monoxide concentration will be less than 50 ppm for oil or gas-fired boilers or 100 ppm for coal-fired boilers; (5) the combustion process will be monitored continuously or at least once each hour that the PCB-contaminated wastes are being burned to determine the percentage of excess oxygen and the carbon monoxide level in the combustion emissions; (6) the primary fuel and waste feed rates are monitored at least every 15 minutes whenever burning the waste; (7) the carbon monoxide and excess oxygen levels are monitored at least once an hour and if they fall below the levels specified, the flow of wastes to the boiler is stopped immediately; and (8) records are maintained that include the monitoring data in (5) and (6) above and the quantities of PCB-contaminated waste burned each month. When burning PCB wastes, the boiler must operate at a level of output no less than the output at which the reported carbon monoxide and excess oxygen measurements were taken. These requirements are similar to those for high efficiency boilers used to burn PCB-contaminated mineral oil.

Persons seeking approval to use this disposal alternative must submit an application to the appropriate EPA Regional Administrator. The application must contain information describing the quantity of waste expected to be disposed of each month, descriptive information about the waste including the concentrations of PCBs and other chlorinated hydrocarbons, the results of a number of standard fuel analyses to determine the nature of the waste, BTU heat value and flash point of the wastes, and an explanation of the procedures to be followed to insure that burning the waste in the boiler will not adversely affect the operation of the boiler such that the combustion efficiency will decrease. The information contained in the applications will help the Regional Administrator to assess whether these high efficiency boilers will adequately destroy these low concentration PCB wastes.

The cost of this alternative is greater than the mineral oil disposal alternative because approval application costs and analytical costs are greater. However, these costs will be less than the cost for Annex I incineration or Annex II chemical waste landfills. As a result, the quantity of low concentration PCB wastes going to Annex I and Annex II facilities should be reduced. In addition, a person whose boiler does not meet these requirements but who can demonstrate that the boiler will destroy PCBs as efficiently as a high efficiency boiler may seek specific approval from the appropriate EPA Regional Administrator under § 761.10(a)(3)(iv).

These wastes are treated differently than PCB-contaminated mineral oil dielectric fluid because they tend to be more varied in composition than contaminated mineral oil. In many cases, these fluids are fire or heat resistant and could reduce PCB destruction efficiency. For example, unlike mineral oil, PCB-contaminated hydraulic fluid will require the addition of *more* primary fuel for it to burn in the manner necessary to destroy the PCBs.

C. Disposal of 50 to 500 ppm PCB Liquids in Chemical Waste Landfills

The rule also provides another new disposal alternative not permitted in the proposed rule. All liquid wastes with less than 500 ppm PCB may be disposed of in chemical waste landfills that comply with the requirements of Annex II. Allowing this additional disposal option for low concentration liquid wastes will reduce disposal costs and increase the availability of Annex I incinerators to destroy high concentration wastes.

This disposal alternative is limited to those low PCB concentration (50–500 ppm) wastes that are not considered ignitable wastes. A waste is considered ignitable if its flash point is less than 60° C (140° F). This limitation is consistent with the proposed Resource Conservation and Recovery Act (RCRA) rules for disposal of hazardous wastes (43 FR 58946, December 18, 1978).

Properly designed and operated chemical waste landfills are capable of containing liquid wastes when the liquids are stabilized in the disposal process or contained in cells of sorbent material, as required by this rule. EPA's Office of Solid Waste recommends mixing liquids with soils or solid wastes in order to stabilize liquid wastes. Alternatively, containers of the liquids may be surrounded by enough inert, sorbent material to absorb all of the liquid in the container should the container leak. These techniques will effectively control the migration of PCBs from the landfill site. Use of such landfills will result in only limited exposures to PCBs. Almost all of the exposure will occur during the liquid stabilization process. This use of chemical waste landfills is consistent with hazardous waste disposal policies being proposed by EPA under RCRA (see 43 FR 58946).

Incineration of low concentration PCB wastes is much more costly. To destroy a small percentage of PCBs, a significant volume of contaminated material must be destroyed. The cost of incineration per pound of PCB may be very high. Disposal of low concentration liquid PCBs in an Annex II chemical waste landfill will greatly reduce these disposal costs, free incineration facilities for burning of high concentration wastes, and produce little increase in environmental or human exposure to PCBs.

Owners or operators of chemical waste landfills already approved by EPA for disposal of non-liquid PCBs and PCB Items will have to request additional approval to dispose of liquids with low-concentrations of PCBs. Guidance on proper procedures for requesting such approval will be provided for these owners or operators. Owners and operators of chemical waste landfills not yet approved for disposal of PCBs will also have to request specific permission to dispose of such liquids.

D. Disposal of Non-Liquid PCBs in Chemical Waste Landfills

EPA has decided to permit the disposal of non-liquid PCBs at any concentration in chemical waste landfills that meet the requirements of Annex II. The Disposal and Marking Rule permitted only persons with contaminated soils and other solids recovered from spills or removed from old disposal sites to use this disposal option. It would be inconsistent not to permit this same disposal option for other non-liquid PCB wastes such as contaminated rags and absorbent materials. These additional solids are estimated to be only a small fraction of the total non-liquid PCB wastes generated. Providing this alternative disposal method will permit more of the currently available incineration capacity to be used for high concentration liquid wastes and will result in little additional human or environmental exposure to PCBs. For these reasons, EPA has made this change in § 761.10(a)(4) of the rule.

In addition to disposal in Annex I incinerators or Annex II chemical waste landfills, dredge materials and municipal sewage sludges that contain between 50 ppm and 500 ppm PCB may also be disposed of by any alternative method approved by the appropriate EPA Regional Administrator (see § 761.10(a)(5)(iii)). This provision is unchanged from the Disposal and Marking Rule, except that it now covers these materials down to 50 ppm.

EPA has received a petition from the State of North Carolina regarding the disposal of contaminated soil and debris from spills (44 FR 13575, March 12, 1979). EPA is required to respond to the petition by June 4, 1979.

The storage requirements of § 761.42 Subpart E apply to all of the low concentration wastes discussed above including substances containing between 50 and 500 ppm PCB and will help provide adequate protection against spills.

E. Batch Testing of Mineral Oil Dielectric Fluid

Testing of mineral oil dielectric fluid and waste oil from sources that are otherwise assumed to contain PCBs at a concentration between 50 ppm and 500 ppm can be performed on samples taken from collection tanks ("batch testing"). This is permitted so that oils from multiple sources can be collected and tested without requiring a separate test of each transformer each time a disposer wants to evaluate his disposal options.

The prohibition against dilution, however, has not changed. The new testing option does *not* permit the deliberate dilution of the collected oil (assumed to contain PCBs above 50 ppm) with PCB-free or low-PCB fluids to reduce the concentration of PCBs in the resultant mixture below 50 ppm. Further, the option does not permit the deliberate addition of PCB wastes with concentrations greater than 500 ppm to the tank in order to avoid the more stringent disposal requirements for high-concentration wastes. If such high-concentration wastes are added to the tank, then the entire tank contents must be disposed of in compliance with requirements for wastes containing 500 ppm PCBs or greater, even if a sample of the aggregate tank contents reveals a concentration below 500 ppm. In this circumstance, the tank contents *cannot* be used as dielectric fluid; the tank contents *must* be disposed of in a high temperature incinerator.

These restrictions are essential to ensure that appropriate measures are taken to destroy or dispose of PCB-contaminated wastes. In developing the final rule, EPA developed a balanced approach to disposal by considering the most appropriate means of disposing of wastes with different PCB concentrations in light of the risks to human health and the environment. Diluting or mixing PCB wastes as described above to avoid proper disposal upsets this balance and is a violation of this rule. The proposed rule would have required testing of each transformer's fluid. The cost of batch testing is substantially less than individual source testing. In addition, permitting testing from collection tanks will result in very little additional exposure of humans or the environment to PCBs.

F. Other Changes in the Disposal Requirements

The disposal requirements for PCB chemical substances and PCB mixtures have been replaced by disposal requirements for PCBs (§ 761.10(a)). This was necessary because of the revised definition of PCBs and the elimination of the definitions of "PCB Chemical Substances" and "PCB Mixtures".

The disposal requirements for PCB Articles other than PCB Transformers and PCB Capacitors have been changed to permit these articles to be disposed of in a chemical waste landfill as well as in high temperature incinerators (§ 761.10(b)(4)). Examples of these articles include pipes, hoses, parts of heat transfer systems, electromagnets, and electric motors. Altogether, these articles account for less than one percent (1%) of the PCBs currently in use in the United States. When these articles are disposed of in chemical waste landfills, they must be drained of free flowing liquid. As a consequence, these articles will contain only small amounts of PCBs. Disposal of these articles in chemical waste landfills will add only small quantities of PCBs to the landfills and will result in little or no additional human and environmental exposure of PCBs.

The final rule has a special disposal provision for hydraulic machines. These machines are difficult to transport as they frequently weigh many tons and can be as large as a small building. In general, only a relatively small portion of the machine is contaminated with PCBs. For these reasons, instead of requiring disposal in a chemical waste landfill, the final rule permits disposal of hydraulic systems as municipal solid waste and salvaging of these machines after draining. The machines must first be drained of all free-flowing liquid. If the fluid contains more than 1000 ppm PCBs, the machines must be flushed with a solvent and thoroughly drained before disposal. After considering the cost of disposing of these machines in chemical waste landfills and the small quantities of PCBs that would remain in a properly drained machine, EPA concluded that disposal as municipal solid waste did not represent an unreasonable risk to health or the environment. For these same reasons, no special storage requirements have been included for properly drained machines.

The final rule also permits PCB Containers that were used only to contain materials or fluids with PCB concentrations between 50 and 500 ppm to be disposed of as municipal solid waste. If these containers are well drained, as required by the rule, only very small quantities of PCBs would remain and these containers could be safely disposed of as municipal solid waste with little added exposure to humans or the environment. For example, if a drum containing 500 ppm liquid waste is drained of 99% of the liquid, less than one gram of PCB would remain in the drum. Disposers of these containers will have to be able to demonstrate that the containers only contained PCBs in concentrations of 50 to 500 ppm.

IV. Changes in Subpart C: Marking of PCBs and PCB Items

The PCB Disposal amd Marking Rule, as promulgated in February 1978, applied only to PCB and PCB Items that contained 500 ppm or greater PCBs. These requirements now extend to all PCB Items (including PCB Containers, PCB Article Containers, PCB Articles, PCB Equipment, and PCB transport vehicles) that contain 50 ppm or greater PCBs. This modification makes the marking and disposal requirements consistent with the final prohibition rule, which generally extends to all PCB Items with 50 ppm or greater PCBs, as discussed above.

The extension of the disposal and marking requirements is essential to ensure that PCB Items regulated under this rule are properly identified, handled, and disposed of to minimize the potential risks of exposure to PCBs. To provide sufficient time to identify and mark PCB Items containing between 50 and 500 ppm PCB, § 761.20(e) provides that these PCB Items must be marked by October 1, 1979.

PCB-Contaminated Transformers are an exception to the policy described above and are not required to be marked. The cost of marking a very large number of PCB-Contaminated Transformers while they are in service would be extremely high. There are about 35 million PCB-Contaminated Transformers and, if it cost $10 to label each one, the total labeling cost would be about $350 million. Also, because EPA assumes that all transformers other than PCB Transformers (which are required to be marked) are PCB-Contaminated Transformers, labels are not necessary. An unmarked mineral oil transformer will automatically be assumed to be a PCB-Contaminated Transformer unless it meets one of the criteria listed in preamble section II.C.1 above. Although transformers at any time can be properly tested and found to be either a Non-PCB Transformer or a PCB Transformer, such testing would generally be performed only when disposal is contemplated. Consequently, labeling to differentiate such transformers from PCB-Contaminated Transformers would have little practical value.

Some PCB-Contaminated Transformers may have already been marked with the PCB Transformer mark (especially in Michigan where State law requires marking for transformers with 100 ppm PCB or greater). There is some concern that the label on the transformer will determine the disposal alternatives. This is to clarify that when a transformer is ready to be disposed of, the owner or operator may choose among the alternative disposal methods applicable to the transformer in question and permitted by this rule. (See preamble section II.C, "Classification of Transformers Under This Rule".)

Marking of large capacitors is relatively straightforward because virtually all large capacitors were PCB-filled until the past few years. Therefore, any capacitor that cannot be shown to be PCB-free by examining label or nameplate information, must be assumed to be a PCB Capacitor and must be marked with the PCB mark.

A new paragraph § 761.20(h), has been added that requires that marks (or labels) be placed on the exterior of PCB Items and transport vehicles so that the marks can be seen by interested persons. This addition corrects an oversight in the original Disposal and Marking Rule.

Section 761.20(i) has been added to clarify that any marking requirements for PCBs at concentrations less than 500 ppm manufactured after [30 days after publication in the **Federal Register**], including PCBs that are byproducts or impurities, will be contained in the exemption EPA grants to permit such manufacture. However, any PCB Article or PCB Equipment into which the PCBs are processed must be marked in accordance with the requirements found elsewhere in Subpart C. Those persons who have submitted petitions to manufacture chemicals with PCB contamination pursuant to the rulemaking procedures for the manufacturing exemptions (43 FR 50905, November 1, 1978) are not required to label any chemical that contains less than 500 ppm PCB until EPA acts on their petition. For example, persons who have petitioned because they manufacture PCBs as a contaminant at less than 500 ppm or a pigment or other commercial chemical product do not have to label that product as containing PCBs until after EPA acts on their petition. Conversely, any containers of any product that contains 500 ppm or greater PCBs must be labeled. This latter requirement was included in the PCB Disposal and Marking Rule (43 FR 7150, February 17, 1978).

V. Changes in Subpart E: Annexes

A. Annex I: Incineration

Section 761.40(a)(2) establishes a new value of 99.9% for the combustion efficiency required of incinerators. This is a correction of the earlier value of 99% efficiency that was specified in the Disposal and Marking Rule. Specifically incinerators operating at the temperatures, dwell times, and excess oxygen concentrations specified in Annex I normally operate at a combustion efficiency of 99.9% or greater. A combustion efficiency of 99.9% thus more accurately represents the true combustion efficiency of Annex I incinerators. All incinerators that have been approved or that are under consideration for approval by EPA are capable of operating at 99.9% combustion efficiency; accordingly, this modification should not disqualify these incinerators or result in additional operating expenses for these facilities. (This change does not mean that those incinerators already approved will be required to reapply for approval to operate.) Combustion efficiency is an effective parameter for evaluating the degree of destruction that occurs in an incinerator, and it is essential that the required value for this parameter accurately reflect expected combustion conditions.

A change has been made to the CO_2 monitoring requirement of § 761.40(a)(7). The Disposal and Marking Rule required continuous monitoring of the CO_2 concentration in the stack gas of the incinerator. The rule has been changed to require periodic CO_2 monitoring as specified by the Regional Administrator. This change was made for two reasons: (1) the high cost of the equipment needed to continuously monitor CO_2; and (2) the insensitivity of the combustion efficiency calculation to variations in the CO_2 concentration.

The automatic shutoff of waste flow that was required by the Disposal and Marking Rule when certain operating deficiencies occurred has been modified. Owners or operators of an incinerator may submit to the Regional Administrator, when they apply for the approval to incinerate PCBs, a contingency plan outlining the corrective steps they will take when operating problems occur. This change provides for greater flexibility for incinerator operators and will result in no increased human or environmental exposure since the contingency plans will be examined on a case-by-case basis by the Regional Administrator for proper safeguards before approval.

A new paragraph, § 761.40(d)(8), has been added to clarify the responsibility of the owner or operator of an approved facility when the ownership of the facility is transferred.

B. Annex II: Chemical Waste Landfills

Section 761.41(b) specifies requirements for operational plans for chemical waste landfills. These requirements have been modified to require delineation of the procedures to be used for the disposal of liquids containing between 50 ppm and 500 ppm PCB. After EPA approves an operational plan, the affected landfill operator must follow those procedures in disposing of PCB wastes.

Section 761.41(b)(3) specifies that the bottom of a chemical waste landfill must be at least fifty feet above the historical high water table. Because the distance between the bottom of the chemical waste landfill and the water table in many areas east of the Mississippi River is far less than fifty feet, EPA Regional Administrators have had to waive this criterion in several situations. While the criterion in the final rule is unchanged from the Disposal and Marking Rule, EPA is proposing a modification of this provision in a separate notice of proposed rulemaking.

The provisions in Annex II of the Disposal and Marking Rule establishing monitoring requirements for surface water (§ 761.41(b)(6)(i)) have been modified to allow the Regional Administrator to designate the surface watercourses that are to be sampled. This minor change eliminates any uncertainty about which watercourses are to be sampled.

Section 761.41(b)(7) includes provisions for leachate collection in chemical waste landfills. The Disposal and Marking Rule specified that the collection system be located under the landfill liner system. The final rule corrects this provision and specifies that the collection system be above the landfill liner system. Collection systems are placed above the liner to capture liquids to protect and reduce hydraulic pressure on the liner system. All chemical waste landfills currently in use have collection systems above the liner.

A new paragraph, § 761.41(c)(7), has been added to clarify the responsibility of the owner or operator of an approved facility when the ownership of the facility is transferred.

C. Annex III: Storage

1. Container Specifications

The requirements of § 761.42(c)(6) have been modified to clarify the five types of Department of Transportation (DOT)-approved containers that can be used to store PCBs and PCB Items. The Disposal and Marking Rule (§ 761.42(c)(6)) stated that containers used to store liquid PCBs must comply with the DOT specifications set out in 49 CFR 173.346, which describe a broad range of containers varying in size from less than one gallon containers to railroad tank cars. Since only five of these container specifications (5, 5B, 6D, 17C, and 17E) are appropriate for such PCB storage, the rule has been modified to refer only to these five DOT container specifications. This change should not be disruptive as industry already generally uses the containers included in these five DOT specifications for PCB storage and handling.

In addition, on August 2, 1978, EPA published a clarification of § 761.42(c)(6) concerning PCB containers that provided for the use of special-sized containers for oversized PCB Articles or PCB Equipment (43 FR 33918). This clarification is incorporated in the final rule.

2. Bulk Storage

A new subparagraph, § 761.42(c)(7), has been added to permit the use of large containers, such as storage tanks, for the storage of PCB liquids. This change is designed to allow safer transfer and storage of bulk PCBs. While the greatest risks of spills and exposure to PCBs may occur during transfer operations, transfers in bulk from storage tank (or tank truck) to storage tank are usually better controlled than transfers to or from drums. Accordingly, the modification should reduce the number of spills and the extent of exposure to PCBs during transfer operations.

To permit bulk storage of liquid PCBs, EPA has had to add to the rule suitable standards for the containers or storage tanks that would be used. The Occupational Safety and Health Administration (OSHA) has prepared comprehensive tank specifications (29 CFR Part 1910.106). These specifications are based on standards developed by organizations such as the American Society of Mechanical Engineers (ASME) and the American Petroleum Institute (API) and are widely recognized as reasonable standards that provide for safe storage of hazardous substances. These specifications, however, are oriented to flammable and combustible liquids, which usually have a specific gravity of less than one. As provided in the OSHA rules, when a liquid's specific gravity is greater than 1.0 (which is the case with PCBs), precaution must be taken to insure that an adequate factor of safety exists when designing new tanks or when evaluating the structural strength of existing tanks. Liquids with such specific gravities are heavier than water and will put greater stress on the tanks. Accordingly, § 761.42(c)(7)(i) requires that this factor be taken into account to insure adequate structural safety of storage tanks used for PCBs.

Owners or operators of bulk storage facilities will have to keep a record of the amounts added to and removed from the bulk containers. The records will be important in tracing waste shipments and enforcing the disposal and storage requirements. This requirement is similar to the requirement promulgated in the Disposal and Marking Rule for individual containers.

Another factor in EPA's decision to allow bulk storage was the high cost of not permitting it. Considering just mineral oil dielectric fluid, there are about 1.73 billion gallons presently in use (see Versar Report). Assuming this oil would be disposed of over a 40 year period and that the cost of storing each 55 gallon drum is $145 (see Versar Report, Disposal and Marking Rule), the annual storage cost would have been about $132 million. This value would have been larger in practice since new mineral oil brought into use after this year would also have been stored in the same way because of contamination from residual PCBs in the equipment.

3. Spill Prevention Procedures

Spill prevention procedures are necessary to provide adequate environmental protection during the use of PCB storage tanks permitted by § 761.42(c)(7). Some of the substances contained in these tanks may qualify as oils under section 311 of the Clean Water Act and, therefore, may be subject to the spill prevention provisions of 40 CFR Part 112. In order to provide equivalent control of PCB liquids that do not qualify as oils, the Spill Prevention Control and Countermeasures (SPCC) provisions of the 40 CFR Part 112 have been incorporated with certain modifications into this rule. A wide cross section of U.S. industry is now using these procedures to protect against oil spills. Extending these requirements to non-oil PCBs should provide substantial environmental protection and should be easily complied with by industry.

Those provisions of 40 CFR Part 112 incorporated in this PCB rule have been modified to adapt them to the PCB activities regulated by § 761.42(c)(7) of this rule. Specifically, the Part 112 oil spill prevention requirements do not apply to tanks smaller than 660 gallons and underground tanks smaller than 42,000 gallons. Because of the risks associated with spills of PCBs, these tank size exemptions do not apply to containers or tanks containing PCBs at concentrations of 50 ppm or greater. The PCB rule also adds the requirement that the area between a storage tank and secondary containment dikes must be impervious to PCBs to prevent groundwater contamination.

One provision of 40 CFR Part 112, the SPCC plan amendment procedures, is not currently applicable to PCBs. These procedures are triggered by a notification requirement for oil spills. Because these notification requirements do not now apply to PCB spills, the SPCC plan amendment procedures are not applicable.

EPA has proposed a spill prevention rule for hazardous substances (including PCBs) under section 311 of the Clean Water Act (43 FR 39276, September 1, 1978). When this spill prevention rule is promulgated, the spill prevention provisions of this PCB rule will be revised to eliminate duplications or inconsistencies.

4. Flood Protection

The Disposal and Marking Rule required that storage areas be above the 100 year flood level. The Agency is considering modifying the PCB rule to include the flood protection guidelines developed by the National Flood Insurance Administration (NFIA) which is part of the Department of Housing and Urban Development. The Agency decided not to change the PCB rule at this time because the Hazardous Waste Regulations proposed under the Resource Conservation and Recovery Act have included a flood protection approach based on the NFIA program. If that approach is adopted when the Hazardous Waste Regulations are promulgated, the Agency will consider adopting a similar flood protection approach for PCB storage areas.

5. Temporary Storage

a. Revisions

The temporary storage of non-leaking PCB Articles and PCB Containers containing leaking articles was permitted for 30 days under the provisions of the Disposal and Marking Rule. This would enable electric utilities and others to consolidate their PCB Items in a central facility and improve management and recordkeeping for PCB wastes. The proposal did not, however, permit PCB Containers of non-liquid wastes, such as contaminated soil, to be placed in temporary storage. Because these containers of non-liquid waste do not pose any greater hazard than the containers of leaking articles, § 761.42(c)(1) of this rule modifies the storage requirements to permit PCB Containers of non-liquid waste to be held in temporary storage for up to 30 days.

Under the final rule, large quantities of low concentration PCB liquids from PCB-Contaminated Transformers must be properly disposed of. The logistics of immediately transporting liquids drained from these transformers to a single, permanent storage facility are frequently difficult. Even though these liquids pose less of a threat to health and the environment when spilled than do more highly concentrated PCB liquids, adequate spill prevention remains essential. The final rule permits the 30 day temporary storage of low concentration (50 to 500 ppm PCBs) liquids at facilities that have a SPCC plan. That SPCC Plan must adequately address storage of PCBs in relatively small containers, such as 55-gallon drums, which is not normally included in such plans. This approach will insure adequate environmental and human health protection and will place little or no additional burdens on facility owners or operators.

The final rule does not allow temporary storage for high concentration PCB liquids (above 500 ppm). Because of the potential harm from an uncontrolled spill, temporary storage of these concentrated liquids is not permitted.

b. Action on Petitions To Amend Rule on Temporary Storage Requirements

Subsequent to the close of the reply comment period, EPA received petitions under section 21 of TSCA from Commonwealth Edison, Consolidated Edison Company, and the Edison Electric Institute to amend § 761.42(c)(1) (43 FR 7150, 7162, February 17, 1978 and 43 FR 33918, 33920, August 2, 1978) to allow temporary storage of PCB substances, mixtures, and PCB-contaminated materials, such as rags and soil. Representatives of EPA met with petitioners on January 24, 1979 and received written materials on that date in support of the petitions. EPA wrote to petitioners on February 9, 1979 and advised them that the Agency considered the petitions to have been filed on January 24, 1979, the date when written and oral information in support of the petitions was received.

The actions on temporary storage of PCBs and PCB Items described in section V.C.5.a. above grant the petitions in part and deny them in part. The petitions are granted as to temporary storage of PCB Containers of non-liquid wastes, such as contaminated soil and rags. Such temporary storage is now permitted under the conditions of § 761. 42(c)(1)(iii). Similarly, the petitions are granted as to temporary storage of low concentration (50 to 500 ppm PCBs) liquids. Such temporary storage is permitted under the conditions of § 761.42(c)(1)(iii). However, the petitions are denied as to temporary storage of high concentration PCB liquids (above 500 ppm). As noted in section V.C.5.a. of this preamble, the risk of potential harm from an uncontrolled spill, or a leak, is too great to permit temporary storage of such high concentration PCB liquids.

D. Annex IV: Decontamination

The decontamination requirements in Annex IV were changed in this rule to require flushing with a solvent containing less than 50 ppm PCB rather than 500 ppm PCB as previously promulgated. This change is based on lowering the cut-off concentration of PCBs from 500 ppm to 50 ppm. This change will further reduce the amount of residual PCBs in decontaminated containers.

E. Annex V: Records and Monitoring

A new paragraph, § 761.45(d), has been added specifically to require chemical waste landfill operators to retain records concerning the operation of the landfill. These records include the identity of the wastes they receive and where the wastes are placed in the landfill. This paragraph does not require the development of any new records but corrects an omission from the Disposal and Marking Rule.

The final rule modifies § 761.45(b) and adds § 761.45(e) to provide for retention of records by owners or operators of high efficiency boilers. The requirements are similar to recordkeeping requirements for other PCB waste disposal alternatives, such as incinerators or chemical waste landfills, and are necessary for enforcement.

VI. Subpart D: Manufacturing, Processing, Distribution in Commerce, and Use Bans

A. Prohibitions

Section 761.30(a) implements TSCA section 6(e)(2)(A), which prohibits the manufacture (including importation), processing, distribution in commerce, and use of PCBs and PCB Items in a manner other than a totally enclosed manner unless authorized under § 761.31 of this rule. This prohibition also applies to the manufacture, processing, and distribution in commerce of PCBs and PCB Items intended solely for export (see preamble section XI below).

Section 761.30(b) implements TSCA § 6(e)(3)(A)(i), which prohibits the manufacture (including importation into the United States) of PCBs after January 1, 1979 unless an exemption is granted for such manufacturers. This prohibition applies to the manufacture (and importation) of PCBs regardless of whether they are manufactured in a totally enclosed manner or they are manufactured solely for export. This prohibition does not apply to PCBs that are imported solely for disposal (see section B.2 below).

Section 761.30(c) implements TSCA section 6(e)(3)(A)(ii), which prohibits both the processing and the distribution in commerce of PCBs and PCB Items after July 1, 1979 unless exemptions are granted for such activities. This prohibition applies to the processing and distribution in commerce of PCBs and PCB Items regardless of whether the Items are processed or distributed in a totally enclosed manner or solely for export. There are three exceptions to these prohibitions.

First, as provided in section 6(e)(3)(C) of TSCA, PCBs or PCB Items that have been sold for purposes other than resale before July 1, 1979, may continue to be distributed after July 1, 1979 in a totally enclosed manner. Therefore, a person who purchases before July 1, 1979, PCB Equipment (such as computers, television sets, or microwave ovens containing PCB Capacitors) for his own use, rather than for resale, may sell that equipment after June 30, 1979.

Second, after July 1, 1979, anyone may process or distribute in commerce PCBs or PCB Items for purposes of disposal in accordance with the requirements of § 761.10. Because TSCA treats disposal separately from processing and distribution in commerce, the processing and distribution in commerce requirements generally are not intended to interfere with the disposal requirements. Section 761.30(c)(2) explicitly states that processing and distribution for purposes of disposal in accordance with § 761.10 may continue after July 1, 1979.

Third, PCBs or PCB Items may be exported for disposal purposes despite the general ban on export of PCBs and PCB Items in § 761.30(c). Section 761.30(c)(3) requires persons to notify EPA at least 30 days before they first intend to export PCB wastes. This provision is discussed further in section B.2. below.

1. Waste Oil Bans

Section 761.30(d) prohibits the use of waste oil containing any detectable concentration of PCBs as a sealant, coating, or dust control agent. Prohibited uses include road oiling, general dust control, as a pesticide or herbicide carrier, and as a rust preventative on pipes. Waste oil is defined as used products primarily derived from petroleum, which include, but are not limited to, fuel oils, motor oils, gear oils, cutting oils, transmission fluids, hydraulic fluids, and dielectric fluids. In the proposed rule, "PCB Sealant, Coating, and Dust Control Agent" was defined (§ 761.2(cc), 43 FR 24813) and was included in the term "PCB" for the purpose of regulating these activities. Because the term "PCB Sealant, Coating, and Dust Control Agent" was deleted from the definition of "PCB" (see preamble section II.A.), it became necessary to specifically regulate these activities in § 761.30.

Persons who process, distribute in commerce, or use waste oil must assume it contains PCBs unless the waste oil has been tested and found to contain no PCBs. Batch testing of waste oils is permitted. Waste oils that contain detectable concentrations of PCBs less than 50 ppm may be used as a fuel, as a feedstock in the production of re-refined oils and lubricants, or for any other purpose except as a sealant, coating, or dust control agent.

The use of waste oil containing any detectable concentration of PCBs as a sealant, coating, or dust control agent is banned because these uses result in rapid, direct entry of PCB into the environment. For example, the run-off from road surfaces frequently goes directly to rivers or streams. Once in the environment, PCB enters the food chain, causing a number of adverse effects. The dumping of waste oil (e.g., in a field) is considered use as a dust control agent and is prohibited by this rule. Waste oil is also used to coat water pipes and as a carrier for pesticides and herbicides. These uses also result in substantial direct entry of PCBs into the environment and are prohibited. Although the PCB concentration in waste oil may be low, the large volume of waste oil that is used in these activities results in a large quantity of PCBs entering the environment. Approximately 6,500 pounds of PCB enter the environment annually just from road oiling activities (see the Versar Report).

B. Changes in § 761.30: Prohibitions

The following changes have been made to § 761.30:

1. Change in the Scope of the Manufacturing Ban

The proposed rule would have considered the manufacture (and importation) of PCB Articles and PCB Equipment as the manufacture and import of PCBs. This approach would have had the effect of prohibiting the production (and importation) of PCB Articles and PCB Equipment after January 1, 1979, under the provisions of section 6(e)(3)(A)(i) of TSCA. A large number of commentors argued that to consider the production of PCB Articles and PCB Equipment to be "manufacture" was inconsistent with TSCA and other rules promulgated under TSCA. In addition, it was argued that if these activities are considered to be "manufacturing" PCBs, the term "processing" would have no meaning, as almost all commerical activities using PCBs prior to final sale or end use would be manufacturing activities.

a. "Manufacturing" Versus "Processing" of PCB Items

After considering the comments, EPA reexamined the "manufacturing" versus "processing" issue and concluded that PCB Article and PCB Equipment production is "processing" of PCBs, not "manufacture" of PCBs. This conclusion is based on an analysis of the activities of manufacturing, processing, distribution in commerce, and use with respect to chemical substances. EPA determined that "manufacturing" a chemical substance involves only the actual creation of the chemical substance (or of a substance contaminated with PCBs). The other activities are distinguished from "manufacturing" because they involve the use of the already existing substance. "Processing" PCBs includes activities such as placing previously manufactured PCBs into capacitors or transformers. While these activities may be referred to as "manufacturing" of PCB Articles, they do not involve the "manufacture" of the PCBs, only the "processing" of PCBs. The "distribution in commerce" and "use" of PCBs generally coincides with the distribution and use of the PCB Articles and PCB Equipment. Thus, the ban of PCB "manufacture" applies solely to the manufacture of PCBs, as defined in § 761.2(s). Bans of all other activities, namely processing, distribution in commerce, and use, apply both to PCBs as a substance and PCB Items. This interpretation of the terms "manufacture" and "process" also accords with the manner in which Congress intended the requirements of section 6(e)(3) of TSCA to be "phased-in" over time.

The change in EPA's use of the terms "manufacturing" and "processing" is reflected in the definition of PCBs. The proposed definition of "PCB" and "PCBs" included both PCB Article and PCB Equipment (see § 761.2(q) at 43 FR 24813). The final rule changes the definition of "PCB" and "PCBs" in § 761.2(s) by applying these terms only to chemical substances (see preamble section II.A. for more detailed discussion). PCB Equipment and PCB Articles are no longer included in the definition of "PCB" and "PCBs" but are included in a separate term, "PCB Items", which is defined in § 761.2(x).

b. Manufacture and Import of PCB Items

The revised interpretation of "manufacture" and "processing" has two main effects. The first is to postpone the effective date of the prohibition under section 6(e)(3) of the manufacture of PCB Articles and PCB Equipment to July 1, 1979 (unless EPA grants an exemption under section 6(e)(3)(B) of TSCA for continuation of such activities beyond that date). The continued production of PCB Articles and PCB Equipment until July 1, 1979, must, however, be performed in a totally enclosed manner in order to avoid the prohibition on non-totally enclosed processing of PCBs of section 6(e)(2). As a practical matter, this means that production of PCB Articles will be prohibited after July 2, 1979, under section 6(e)(2) as a non-totally enclosed processing of PCBs. In general, PCB Equipment is produced in a totally enclosed manner and so this activity would not be prohibited until July 1, 1979. The practical effect of the change, then, will be to allow continued production of PCB Equipment (such as television sets and microwave ovens) until July 1, 1979 (see preamble section VIII below).

A second effect relates to the importation of PCB Articles and PCB Equipment; here the issues are more complex. The TSCA definition of "manufacture" includes importation (see section 3(7) of TSCA). This means that the importation of any PCB or PCB Item is equated with manufacture. A literal interpretation of this definition in implementing TSCA section 6(e)(3)(A)(i) would mean that no person would be able to import any PCB or PCB Item after [30 days after publication in the **Federal Register**]. This would create an inequity between domestic manufacturers and importers of PCB Items. Specifically, domestic manufacturers of PCB Items could continue to manufacture and distribute those PCB Items in commerce until July 1, 1979, when the ban under section 6(e)(3)(A)(ii) is effective, while importers would be prohibited from conducting the same activity after [30 days after publication in the **Federal Register**].

The most straightforward way to eliminate this inequity is to delay the effective date of the prohibition on the importation of PCB Items until July 1, 1979. This approach would eliminate the inequity for importers of PCB Equipment but create a different inequity for the importers of PCB Articles. Domestic production of PCB Articles, such as PCB Capacitors and PCB Transformers, is banned as of [30 days after publication in the **Federal Register**] (even though such production is PCB processing) because this type of production cannot be performed in a totally enclosed manner. (Non-totally enclosed processing and other activities are prohibited after July 2, 1979, by section 6(e)(2) of TSCA.) If the import prohibition for PCB Articles is delayed, PCB Articles could be imported into the U.S. even though they could not be manufactured in the U.S. The continued importation of PCB Articles would increase both the disposal problem associated with PCB Capacitors and the problems associated with use and disposal of PCB fluids in transformers.

Because of the inequities and disposal problems associated with continued importation, EPA is banning importation of PCB Articles after July 2, 1979. Persons wishing to import PCB Articles may petition EPA for an exemption from this ban. This rule does permit continued importation until July 1, 1979, of PCB Equipment, such as television sets and microwave ovens, since these items can be manufactured domestically during this period as they involve "processing" PCB in a totally enclosed manner. The effect of this rule is essentially to treat domestic and foreign manufacturers of PCB Articles and PCB Equipment equally. Such equal treatment was intended and desired by Congress.

From a strict statutory perspective, any importation of PCBs in any form, including in PCB Items, is "manufacturing" of PCBs and prohibited after [30 days after publication in the **Federal Register**], by TSCA section 6(e) (2) and (3). Although domestic production of PCB Items is best described as PCB "processing", importation of such items is best described as importation of PCBs in the item. The alternative would be to wholly exclude such importation from the coverage of section 6(e), a manifest absurdity. But just as Congress obviously did not intend such exclusion, so too it did not intend discriminatory treatment. EPA, therefore, construes section 6(e) as authorizing it to impose parallel restrictions on PCB Item production and importation and this is what has been done.

While domestic manufacturers and importers both may continue to build or import PCB Equipment (but not PCB Articles) until July 1, 1979, EPA will strictly enforce the prohibition under TSCA section 6(e)(3)(A)(ii) of processing and distribution in commerce of PCBs and PCB Items, including PCB Equipment, after July 1, 1979. Accordingly, no one will benefit by creating stockpiles of these items in the next several months. The only exceptions to these July 1, 1979 prohibitions will be those activities for which EPA grants an exemption.

Any PCBs or PCB Items imported pursuant to this rule must comply with the import requirements and all other requirements of this rule.

2. Import and Export of PCBs and PCB Items for Disposal

The proposed rule would have prohibited any import or export of PCBs or PCB Items for any purpose. EPA has reviewed this proposed policy and has decided that because of the many potential advantages of an open border policy with respect to disposal of PCBs, that EPA will adopt such a policy for at least one year.

In theory, an open border policy would be advantageous to both the United States and foreign countries, especially Canada. Generators of PCB wastes would be able to select the PCB disposal site that offers the most reasonable transportation and disposal costs. The success of such a policy depends, however, upon the availability of facilities in other countries to safely dispose of PCB wastes. EPA is concerned that foreign disposal alternatives may not adequately destroy the PCBs and create a threat to human health and the environment in the United States.

To date, the United States has approved seven PCB disposal sites and is actively involved in evaluating other potential sites. Other nations have not made as much progress. If the United States were to adopt an open border policy without any qualifications, there may be no incentive for other nations to develop PCB disposal sites. The United States would probably receive a disproportionate share of the international PCB wastes. This disparity could overload existing U.S. capacity and impede public acceptance of PCB disposal sites.

The one year time limit on the open border policy will provide other nations an opportunity to establish PCB disposal sites. At the end of the one year period, EPA will examine the progress made by other nations in establishing and operating safe PCB disposal sites and determine if extension of the open border policy is appropriate.

The final rule, therefore, allows the import and export of PCB wastes for disposal for one year. All imported PCB wastes must be disposed of in accordance with Subpart B of this rule. In preparing this final rule, EPA has reviewed whether regulation of imported and exported PCB wastes for disposal should be accomplished under section 6(e)(1) of TSCA or under section 6(e)(3). While section 6(e)(3)(A)(i) could be read to allow regulation of the import of PCB wastes for disposal, section 6(e) treats PCB disposal as a separate matter under section 6(e)(1). Both the import and export of PCB wastes for disposal may be regulated under section 6(e)(1), which allows comprehensive regulation of the disposal of PCBs. Accordingly, EPA has elected to regulate import and export of PCB wastes for disposal under section 6(e)(1). Since the requirements governing disposal of PCB wastes must be complied with for all imported PCB wastes, no unreasonable risks should result. Moreover, proper disposal in this country provides protection against possible hazards from improper disposal elsewhere.

Other imports and exports of PCBs and PCB Items are regulated as elsewhere described in this preamble under sections 6(e)(2), 6(e)(3), and/or section 12. All imports and exports of PCBs and PCB Items remain subject to the applicable disposal and marking requirements under section 6(e)(1).

Under RCRA, EPA expects to establish a manifest system for hazardous wastes that will monitor the disposal of PCBs and other hazardous wastes imported into the U.S. This system should be in effect in 1980. No notification system for imports of PCB wastes for disposal will be established in this rule because of potential confusion with the forthcoming RCRA program. All importers of PCB wastes will be required to maintain records, as provided in Annex VI of this rule.

With respect to exports, § 761.30(c)(3) of this rule requires that persons exporting PCBs and PCB Items for disposal notify EPA at least 30 days before the first export of wastes. The initial notice should identity the owner of the waste, the expected annual volume of wastes to be exported, a description of the intended methods of disposal, the precautions to be taken to control release into the environment, and the identity of the receiver of the wastes. Quarterly reports of actual waste shipments are also required. For each successive year, the volume of wastes to be exported, if any, must be estimated. These reports are required pursuant to the authority in section 6(e) and 12(a) of TSCA. Additional reports under section 12(b) of TSCA would not be required for the export of these wastes. Unlike other exports of PCBs, export for disposal under this rule will not present an unreasonable risk to the United States because of the controls on such export contained in the rule and the fact that such export will only be for the purpose of disposal or destruction of PCBs.

EPA will carefully monitor the results of allowing the import and export of PCB waste. One future alternative may be to allow disposal only in countries whose facilities meet certain criteria arrived at through bilateral agreements. Closing the United States border to shipments of PCB wastes at this time, however, could have serious adverse effects on the environment by making safe disposal of PCBs more difficult. In particular, barring import of PCBs for disposal could make export for disposal impossible and thereby eliminate what in many cases would be the most desirable disposal alternative. Many generators of hazardous waste materials located near the U.S.-Canadian border find that the nearest disposal site is in the other country. An open border policy will allow import and export of such wastes to continue and maximize the opportunities for appropriate disposal.

For a general discussion of exports of PCBs, see preamble section XI, below. Import or export of PCBs or PCB Items for purposes of disposal remain subject to the other provisions of this rule.

C. Other Issues

1. PCB Impurities and Byproducts

The prohibitions in § 710.30 include a prohibition of the "manufacture" of "PCB" or "PCBs" as defined in § 761.2(s). This prohibition applies to the deliberate production of PCBs whether in large quantities for use in transformers and capacitors or in small quantities for research. Furthermore, the prohibition applies to the manufacture of any substance or mixture that contains PCB at 50 ppm or greater, including PCB that is an intermediate or "impurity" or "byproduct", as defined by § 761.2(k) and (c), respectively. While the production of PCBs under such circumstances may not be intentional and may have no independent commercial value, section 6(e) of TSCA applies to *any* production of PCBs and, therefore, covers such activities. Similarly, processing, distribution in commerce, and use of PCBs which are impurities or byproducts are subject to sections 6(e)(2) and (3) of TSCA.

The proposed rule prohibited activities involving PCB intermediates, impurities and byproducts under sections 6(e)(2) and (3) of TSCA. In response to questions on this point at the informal hearing, EPA made clear that such activities are subject to the rule. This discussion is intended to clarify further that the manufacturing, processing, distribution in commerce, and use bans of sections 6(e)(2) and (3) of TSCA apply whenever PCBs are present as intermediates, impurities, or byproducts at a concentration of 50 ppm or greater.

Some manufacturers commented that they interpreted the proposed rule to allow the creation of PCBs in concentrations greater than 50 ppm as an intermediate, impurity, precursor, or byproduct in a reaction process as long as the PCB concentration in any final byproduct or end product is below 50 ppm. The intent of the proposed rule was to prohibit such manufacture. All manufacturing or processing operations must be adequately controlled so that PCBs are not present at concentrations greater than 50 ppm at any point in the manufacturing process except when concentrating waste streams, as discussed below.

As discussed earlier in section II.B. of this preamble, several processes for the manufacture of chlorinated organic substances unintentionally create PCBs. EPA is aware of several cases in which the PCBs appear as impurities at concentrations greater than 50 ppm in the final product. To reduce the level of PCBs that are impurities in these chemical products, selection of ingredients and process techniques usually have to be altered. In some cases, more careful quality control of the production operations can help avoid unwanted impurities and byproducts.

Two groups of chemical products are most affected by controls on impurities and byproducts: pigments and other chlorinated chemicals. The impact on pigments is better understood because the industry became aware of the problem earlier than other potentially affected industries and provided extensive information and comments on the impact of the proposed rule. The PCB contamination of pigments is discussed further in preamble section IX.G. The impact on the production of other organic chemicals is not as well known. Only a few companies commented on the proposed rule, and available data are limited.

The manufacture of PCBs as intermediates, impurities and byproducts almost always involves some human and environmental exposure. Unless the PCBs are created in a totally enclosed, continuous reaction process, production workers will be exposed and there may be PCBs in air emissions and other effluents. The processing, distribution in commerce, and use of the chemicals containing PCBs will also cause exposure to PCBs among process workers and others who handle and use the chemicals. Controls that exist on worker exposure and/or handling and disposal practices are usually related to the primary chemical, not the PCBs contained in the chemical, which means that exposure to the PCBs often is uncontrolled.

As explained below, persons may petition for an exemption from this manufacturing ban pursuant to the Agency's interim procedures (43 FR 50905, November 1, 1978). In addition, the processing, distribution in commerce, and use of PCBs in a non-totally enclosed manner is prohibited after July 2, 1979, unless authorized and *all* processing and distribution of such PCBs as byproducts and impurities are prohibited after July 1, 1979, unless a specific exemption from the ban is granted by EPA.

Section 761.30(c)(2) provides that PCBs may be processed and distributed in commerce for purposes of disposal in accordance with the requirements of § 761.10. This provision is intended to apply to the concentration of waste streams and allow the concentration of PCBs to exceed 50 ppm in waste stream as long as the waste stream is disposed of in accordance with this rule. The following illustrates this. A product is manufactured that contains 20 ppm PCB. It is then processed to reduce the PCB concentration to 5 ppm. As a result of the processing, a waste stream is created that contains 100 ppm PCB. As long as this waste stream is disposed of in accordance with this rule, the manufacturer does not have to apply for an exemption. If the initial product contains more than 50 ppm PCB, however, the manufacturer must apply for an exemption from the manufacturing prohibition. Section 761.30(c)(2) only applies to byproducts or other wastes that are intended for disposal.

To clarify the relationship of the prohibitions of sections 6(e) (2) and (3) to intermediates, byproducts, and impurities, the terms "manufacture for commercial purposes" and "process for commercial purposes", defined in § 761.2 (bb) and (dd) of the proposed rule, have been deleted. These definitions were intended to exclude from the rule a very limited number of activities (e.g., the chlorination of municipal sewage discharges) that may result in or involve PCB concentrations below 50 ppm. In the applicability section (§ 761.1(b)) the final rule states that unless otherwise specified in the rule itself, the term "PCB", as used in the rule, is intended to include only substances or combinations of substances with 50 ppm or greater PCBs. Accordingly, it should be clear that such activities are not within the scope of the rule. As a consequence, the definitions concerning "commercial purposes" are not necessary and may be confusing, especially because § 6(e) is not limited by the statute to activities "for commercial purposes"

2. Disposal of Small PCB Capacitors

The PCB Disposal and Marking Rule excluded most small PCB Capacitors, primarily those contained in small appliances and fluorescent light ballasts, from special disposal requirements. These small capacitors may be disposed of as municipal solid waste. Only small capacitors owned by persons who manufacture capacitors or PCB Equipment are subject to special disposal requirements.

These requirements are not changed by this final rule. EPA has not identified a feasible regulatory alternative that would result in disposal of a substantial portion of the remaining small PCB Capacitors in facilities other than municipal solid waste sites. In addition, the random disposal of PCB Equipment in municipal solid waste sites by householders and other infrequent disposers does not present an environmental hazard. Accordingly, EPA has no current plans to further regulate the disposal of these small capacitors.

However, the disposal of large quantities of small PCB Capacitors by commercial and industrial activities poses a somewhat larger environmental risk. Therefore, EPA encourages commercial and industrial firms that use and dispose of large quantities of small PCB Capacitors to establish voluntarily a collection and disposal program that would result in the waste capacitors going to chemical waste landfills or high temperature incinerators. Proper disposal of small PCB Capacitors is mandatory for all manufacturers of PCB Equipment. This would result in better environmental control than normal municipal solid waste disposal by preventing large concentrations of capacitors from being placed in sanitary landfills. It should also be noted that any PCB spillage that might result from failure of or from damage to a large number of small capacitors could be considered as illegal disposal, which is the case for other spills of PCBs.

3. State Preemptions

In the Disposal and Marking Rule, EPA stated that State and local requirements regarding disposal of PCBs are exempt from Federal preemption as long as the requirements are not less restrictive than those prescribed by EPA. EPA took this position to avoid interfering with existing PCB disposal requirements in Michigan, Oregon, Indiana, Minnesota, and Wisconsin, where the State requirements are at least as stringent as the Federal requirements.

In the past several months, EPA has become concerned that actions by local and State governments to prohibit disposal of PCBs and other substances in their jurisdictions could frustrate the national goal of properly disposing of hazardous chemical substances. While EPA has always believed that States should have the right to set pollution control standards more restrictive than the Federal standards, it would be a matter of national concern if this principle were to become the basis for refusal by States to share in the national responsibility for finding safe means for the proper disposal of hazardous substances. EPA has decided not to make any changes in its PCB preemption policy at this time. However, EPA will be considering the preemption issue further in its administration of the Resource Conservation and Recovery Act.

VII Relationship of Section 6(e)(2) to Section 6(e)(3)

Section 6(e)(2) of TSCA prohibits manufacturing, processing, distribution in commerce, and use of PCBs after January 1, 1978, unless conducted in a totally enclosed manner. Section 6(e)(2)(B) provides that the Administrator may, by rule, authorize continuation of an otherwise prohibited activity if the Administrator finds that the activity "will not present an unreasonable risk of injury to health or the environment"

Section 6(e)(3) prohibits *all* manufacturing, processing, and distribution in commerce of PCBs (including activities conducted in a totally enclosed manner). The manufacturing prohibition is effective on July 2, 1979 and the other prohibitions are effective on July 1, 1979. Section 6(e)(3)(B) authorizes the Administrator to exempt activities from section 6(e)(3) prohibitions if he finds that the activity will not result in an unreasonable risk to health or the environment *and* that good faith efforts have been made to develop a substitute for the PCB.

It is obvious that, with respect to manufacturing, processing, and distribution in commerce, the provisions of section 6(e)(2) are entirely duplicative of the corresponding provisions of section 6(e)(3) once these provisions of section 6(e)(3) become effective. For example, once the manufacturing prohibition of section 6(e)(3) is effective the manufacturing prohibition of section 6(e)(2) adds nothing whatever to protection of health and the environment since section 6(e)(3) is broader in coverage and somewhat more restrictive in terms of waivers (exemptions). Similarly, on July 1, 1979, the section 6(e)(3) prohibitions of processing and distribution in commerce entirely supersede the corresponding prohibitions in section 6(e)(2). It is clear that with respect to manufacturing, processing, and distribution in commerce of PCBs, Congress intended section 6(e)(2) as only an interim measure. Moreover, to continue to implement the section 6(e)(2) prohibitions on these activities after the corresponding prohibitions of section 6(e)(3) are effective would result in waste and confusion with absolutely no increase in protection from PCBs.

Therefore, EPA will consider the prohibitions in section 6(e)(2) to be superceded and no longer in effect when the corresponding prohibitions of section 6(e)(3) for each PCB activity go into effect. What this means is that the section 6(e)(2) prohibition on manufacturing of PCBs is considered to be no longer in effect now that the section 6(e)(3) prohibition on manufacturing is in effect. The provisions of section 6(e)(3) will be considered the exclusive authority under section 6(e) to prohibit PCB manufacturing. However, the section 6(e)(2) prohibitions on processing, distribution in commerce and use *are* effective as of July 2, 1979. The processing and distribution in commerce prohibitions of section 6(e)(2) will be considered to continue in effect until July 1, 1979, when they will be superceded by section 6(e)(3). Because the section 6(e)(2) *use* prohibition has no counterpart in section 6(e)(3) it remains in effect indefinitely.

VIII. Authorizations and Exemptions

A. Explanation of Authorizations and Exemptions

Section 6(e) of TSCA provides for two types of exceptions to the prohibitions of PCB activities: authorizations and exemptions. The purpose of this discussion is to clarify the distinctions between these exceptions and explain EPA's policy to simplify implementation by having a combined procedure for authorizations and exemptions.

An authorization is an exception to the TSCA section 6(e)(2) January 1, 1978 ban of non-totally enclosed activities. To authorize an activity, EPA must find that continuation of the activity does not present an unreasonable risk of injury to human health or the environment. Since the intent of the law is for PCB activities to be banned, it must be clearly evident that the risk from an activity is not unreasonable. In the absence of such evidence, an activity is banned.

Although not subject to section 6(c)(1) of TSCA, EPA used the criteria in section 6(c)(1) to determine whether or not the risk from a non-totally enclosed activity is "unreasonable". These factors include: (1) the effect of such substance or mixture on health and the magnitude of exposure of human beings to such substance or mixture, (2) the effects of such substance or mixture on the environment and the magnitude of the exposure of the environment to such substance and mixture, (3) the benefits of such substance or mixture for various uses and the availability of substitutes for such uses, and (4) the reasonably ascertainable economic consequences of the rule, after consideration of the effect on the national economy, small business, technological innovation, the environment, and public health.

An exemption is an exception to either (1) the TSCA section 6(e)(3)(A)(i) January 1, 1979 complete ban of all PCB manufacture or (2) the TSCA section 6(e)(3)(A)(ii) July 1, 1979 complete ban of all PCB processing and distribution in commerce. To grant an exemption, EPA must determine both that an unreasonable risk is not present and that good faith efforts have been made to develop substitutes for the PCBs used in the activity to be exempted.

In addition to the difference in criteria for granting these two exceptions, there are several other important distinctions between an authorization and an exemption.

First, an authorization may be valid for any time period that EPA finds appropriate, but an exemption is only valid for one year and must be granted annually through a formal rulemaking. However, the complete bans of manufacture, processing, and distribution in commerce contained in section 6(e)(3) of TSCA supercede the corresponding bans contained in section 6(e)(2), as explained above. Since EPA must make more stringent findings under section 6(e)(3) than under section 6(e)(2), there is no reason to require petitioners to have an authorization if they have been granted an exemption for the same activity (see preamble section VII). Therefore, a PCB processing or distribution in commerce activity cannot be authorized after July 1, 1979. After this date, persons who process or distribute PCBs *must* petition for and be granted an exemption annually by EPA in order to continue these activities.

Second, EPA may propose and promulgate an authorization without a specific request from the persons who will benefit from the authorization. This is not the case for exemptions, which must be petitioned for by those who would benefit from them. The requirements regarding exemption petitions are discussed below.

Third, because section 6(e)(3) of TSCA completely bans the manufacture, processing, and distribution in commerce of PCBs and not the use of PCBs, all PCB use activities are covered only by section 6(e)(2) of TSCA. This means that a use activity never needs an exemption, and, therefore, must fall into one of three categories: (1) totally enclosed with no need for an authorization; (2) not totally enclosed and authorized; or (3) not totally enclosed and not authorized. Only the third group of use activities is prohibited by this rule. Activities that are included in the first two categories are described in section IX of the preamble, while those in the third category are described in section X.

1. Manufacturing Exemptions

No exemptions are promulgated in this rule. These are being handled in a separate rulemaking. The rulemaking procedures for PCB manufacturing exemptions were printed in the **Federal Register** on November 1, 1978, at page 50905. Examples of manufacturing activities that require an exemption to continue after July 2, 1979, include, but are not limited to: the manufacture of PCB for use in transformers or capacitors; the manufacture of PCB in small quantities for research and development; the manufacture of PCB for use in microscopy; the manufacture of PCB as an impurity or byproduct in or associated with other chemicals (e.g., pigments); and the importation of PCBs, including bulk form or in mixtures and PCB Articles for any purpose other than disposal. As discussed in section VI.B.1 above, importation of PCB Equipment may continue until July 1, 1979.

Persons who have submitted petitions for a manufacturing exemption in accordance with the November 1, 1978, rulemaking procedures will not be subject to the PCB manufacturing ban until EPA acts upon their petitions (see 44 FR 108, January 2, 1979). Many of the petitions are moot because of changes in the final rule that permit the manufacture of PCB Equipment until July 1, 1979. These manufacturers are required to comply with all other applicable portions of this rule, such as requirements for disposal, marking, storage, and recordkeeping.

2. Processing and Distribution in Commerce Exemptions

In the near future, EPA will issue procedures for applications for exemptions from the processing and distribution bans, which are effective July 1, 1979. The procedures may incorporate revisions from those applicable to manufacturing exemptions. Under the existing procedures, each person who wants an exemption must submit a separate petition. EPA is considering revising this requirement to reduce the number of individual petitions because substantially more persons will be affected by the processing and distribution bans than by the manufacturing ban. In addition, EPA anticipates that the petitions will fall into several principal categories. Instead of requiring petitioners to duplicate efforts in cases where their requests are essentially identical, EPA may accept certain class petitions submitted on behalf of more than one petitioner. Trade associations for example, may be permitted to develop a single petition, as appropriate, on behalf of their members, or manufacturers or processors may be permitted to petition on behalf of persons distributing their products.

Activities that will require an exemption from the July 1, 1979, processing and distribution in commerce bans include, but are not limited to: the manufacture of PCB Equipment; the sale of PCB Equipment; the sale of PCB Capacitors; the processing and distribution in commerce of PCBs for servicing PCB Transformers, PCB-Contaminated Transformers, railroad transformers, mining equipment, electromagnets, and hydraulic equipment; the processing and distribution in commerce of pigments and other chemicals that contain 50 ppm or greater PCB; and the processing and distribution in commerce of PCBs for microscopy and in small quantities for research and development.

B. General Changes in § 761.31: Authorizations

Three changes have been made from the proposal that affect all authorizations. These changes are discussed here while changes in individual authorizations are discussed in section IX of this preamble.

1. Reporting and Recordkeeping Requirements

Virtually all reporting and recordkeeping requirements have been deleted from § 761.31. Several proposed authorizations would have required persons to submit reports to EPA and to retain records for a variety of non-totally enclosed activities. EPA recognizes the burden on manufacturers and others who would have been required to prepare and maintain these records and has determined that these requirements are largely unnecessary, because most of the information will be submitted in the annual petitions for exemptions. The only exceptions to this policy are owners of railroad transformers, hydraulic systems, and heat transfer systems who must retain records of the PCB analyses that they are required to perform.

2. Length of Use Authorizations

Unlike all other activities that may be subject to an authorization under TSCA section 6(e)(2)(B), use activities are not prohibited under TSCA section 6(e)(3)(A). Accordingly, there is no automatic limit to the length of use authorizations. In deciding how long to authorize each use, EPA believes that it should have the opportunity to review each use in a timely way to ensure that there is no unreasonable risk associated with its continuation. In addition, improved technology or development of new PCB substitutes could reduce the need for the authorization. Accordingly, EPA proposed a five-year limit on most use authorizations. The final rule has generally extended this period to five and one-half years so that the expiration date for authorizations will coincide with the expiration of the processing and distribution exemptions. This change will permit EPA to combine administrative procedures, and thereby reduce administrative costs. Several use authorizations have shorter periods as explained under section IX below.

Since, as noted earlier, the processing and distribution prohibitions of TSCA section 6(e)(2) expire on July 1, 1979, authorizations for these activities will expire on the same date. Thereafter, these activities will be subject to TSCA section 6(e)(3) and will require annual exemptions to continue.

3. Changes in § 761.46: Annex VII

Annex VII, which provided for PCB Exposure and Control Plans, has been deleted. The proposed Annex would have imposed special requirements on persons authorized to continue activities in other than a totally enclosed manner. Specifically, Annex VII would have required detailed plans for handling PCBs, preventing spills, and otherwise reducing human and environmental exposure. The final rule no longer requires such plans because EPA is developing similar requirements under section 311 of the Clean Water Act (see proposed Spill Prevention Control and Countermeasure Plan Rule, 43 FR 39276, September 1, 1978).

IX. Specific Authorizations

Activities that are regulated by this rule and the effect of the rule on these activities are summarized in Table 3. The data referred to in this section are in the Versar Report, which is available from EPA's Office of Industry Assistance at the address given at the beginning of the preamble.

In relationship to activities regulated by this rule, dilution of PCBs is prohibited unless otherwise specifically provided for in the rule. This prohibition is necessary to prevent an unreasonable risk of human and environmental exposure to PCBs. If dilution was permitted, it would be possible to dilute all PCB liquids so that their disposal would no longer be controlled by this rule. This is clearly an unacceptable alternative since it could result in all existing PCBs entering the environment. However, for several authorized activities, dilution of PCBs is essential to the intended performance of the activities and is not performed with the intent of evading the disposal requirements for PCBs. For these activities only, dilution of PCBs is permitted and the disposal of liquid is governed by its final PCB concentration rather than its beginning PCB concentration. The following authorized activities are permitted to dilute PCBs: (1) Servicing of transformers (with restrictions); (2) Servicing of railroad transformers; (3) Use in heat transfer systems; (4) Use in hydraulic systems; (5) Processing and use of pigments; and (6) Use in natural gas.

The exemption review process for the manufacturing, processing, and distribution in commerce bans will also evaluate the need for dilution in the performance of PCB activities. Any decisions to permit dilution in exempted activities will be stated in the exemption, if granted.

A. Servicing Transformers (Other Than Railroad Transformers)

EPA considers the use of transformers as use in a totally enclosed manner. Accordingly, the use of PCBs in transformers may continue indefinitely. In addition, in this rule EPA authorizes the routine servicing of PCB Transformers (as defined in § 761.21(y)) and the routine servicing and rebuilding of PCB-Contaminated Transformers (as defined in § 761.2(z)) subject to certain conditions. The rule also authorizes the processing and distribution in commerce of PCBs for servicing transformers. The following is a summary of EPA's findings and reasoning behind these decisions.

Most large electrical transformers are designed to operate with the current-carrying coils immersed in a dielectric fluid. In the past, most transformers used in buildings or other critical fire control locations were filled with non-flammable dielectric fluids containing PCBs as a major component. These PCB dielectric fluids are known by the generic term "askarel" and have been in common use since the 1930's. Currently, some 140,000 transformers, or less than one percent of all large electrical transformers in service, use askarel dielectric fluid.

PCB Ban Rule Actions

Activity	Totally enclosed	Authorized by rule [1]	Prohibited by rule	Exemption required	Type of PCB activity [2]
PCB Transformers	U (except servicing).	P, D, U (servicing).	M, Rebuilding	P, D	PCB.
PCB-Contaminated Transformers	U (except servicing).	P, D, U (servicing).		P, D	Contamination.
Railroad Transformer		P, D, U	M	P, D	PCB & Contamination.
Mining Equipment		P, D, U—1/1/82.	Miner Rebuilding (1/2/80).	P, D	PCB.
Heat Transfer		U	M, P, D		Contamination.
Hydraulic Systems		P, D, U	M	P, D	Contamination.
Carbonless Copy Paper		U—unlimited	M, P, D		PCB.
Pigments		P, D, U—1/1/82.	M	M, P, D	Contamination.
Electromagnets	U (except servicing).	P, D, U (servicing).	M, Rebuilding	P, D	PCB.
Natural Gas Pipeline Compressors		U—5/1/80	M, P, D		Contamination.
Small Quantities for R&D		P, D, U	M	M, P, D	PCB.
Microscopy		P, D, U	M	M, P, D	PCB.
PCB Capacitors	D, U		M, P	D	PCB.
PCB Equipment	M, P, D, U			P, D	PCB.
Process Contamination			M, P, D, U	M, P, D	Contamination.
Imports & Exports (except for disposal)			M, P, D	M, P, D	PCB & Contamination.
Dust Control, Sealants & Coatings (from waste oil with *any* PCB).			M, P, D, U		Contamination.

---

[1] Unless otherwise noted, all authorizations expire July 1, 1984. Processing and distribution in commerce require exemptions after July 1, 1979.

[2] "PCB" indicates use of "pure" PCBs (e.g., askarel dielectric fluids) while "Contamination" indicates PCB contamination at concentrations greater than 50 ppm in non-PCB substances or mixtures from previous use of "pure" PCBs.

Abbreviations: M—Manufacturing, P—Processing, D—Distribution in Commerce, U—Use.

Reproduced from best available copy.

A transformer is essentially a large, sealed can. The only time the can is deliberately opened is when the transformer requires certain types of servicing. Except in the event of a catastrophic failure or other extraordinary circumstance, use (except servicing) of transformers is performed in a totally enclosed manner and, as such, does not require an authorization. Under this rule, use of PCBs in transformers may continue indefinitely because this is a totally enclosed use.

1. General Discussion of Transformer Servicing

Servicing of transformers does result in exposure to PCBs. There are two general categories of servicing: routine servicing and rebuilding. Routine servicing includes testing the dielectric fluid, filtering the fluid, and replacing gaskets. Routine servicing often requires the removal of some dielectric fluid and then the return, or replacement, of that fluid. These activities result in some human and environmental exposure, but the exposure is usually limited to exposure of workers to small quantities of PCB. Good management practices and protective clothing should result in only very low levels of exposure to PCBs during routine servicing.

Rebuilding occurs after a transformer has failed or after an inspection indicates that it will soon fail. Rebuilding is an open process that involves draining the transformer, removing and disassembling the core, reworking the coil or rewinding a new coil, reassembling the core, and refilling the transformer with new fluid. Unless extraordinary precaution is taken, the shop personnel responsible for rebuilding the transformer are exposed to PCBs since the inner parts of the transformer are saturated with PCBs. Volatilization of the PCBs and leaks from both the transformer and PCB handling result in environmental exposure to PCBs.

Worker exposure during rebuilding can be moderated by protective equipment, but is inevitably greater than the exposures during routine servicing. Volatilization is difficult to control because of the large surface area exposed. Unless carefully controlled, the leaks may contaminate work areas and storage yards and may reach watercourses through uncontrolled runoff and drainage systems. Cleaning the inner surfaces of the transformers with solvents during the rebuilding process, cleanup of spillage and drippings, and scrapping of unserviceable components all increase the production of liquid and non-liquid PCB wastes. In addition, the old coil must be disposed of separately from the casing, potentially increasing the environmental exposure to PCBs.

2. PCB Transformers

In developing the proposed rule, EPA considered three principal options for PCB Transformers: (1) prohibit both routine servicing and rebuilding; (2) permit routine servicing but prohibit rebuilding; and (3) permit both routine servicing and rebuilding. Option 1 would result in the greatest reduction of potential PCB exposure. Prohibition of routine servicing would, however, probably significantly increase the chances of catastrophic transformer failure because of inadequate maintenance. This hazard and the resulting exposure to PCBs may present far greater risks to health and the environment than that associated with the minimal PCB exposure during routine servicing. Option 3 could result in significant human and environmental exposure to PCBs from rebuilding transformers, as explained above. For these reasons, EPA has chosen a course of action based upon Option 2, permitting routine servicing but prohibiting rebuilding of PCB Transformers.

Routine servicing will result in minimal exposures to PCBs and allow the use of most existing transformers to continue through their useful lifetimes. EPA has concluded that this activity does not pose an unreasonable risk to human health or the environment. However, any servicing (including rebuilding) of PCB Transformers that involves removing the coils from the casing is prohibited by the rule. This prohibition will cost about $12 million the first year and steadily less each year thereafter. Removing the coils substantially increases PCB exposure. Considering the PCB exposure that would result if such servicing (including rebuilding) was permitted, EPA believes that these costs are justified by the increased risks of harm to human health and the environment and concludes that such servicing of PCB Transformers presents an unreasonable risk.

3. PCB-Contaminated Transformers

As explained below, rebuilding transformers with less than 500 ppm PCB is permitted. Because of the relatively low concentrations of PCBs, EPA believes that the risks of further contamination of the environment with PCBs due to such rebuilding will be negligible. Because these transformers comprise over 99% of all large electrical transformers, the economic impact of a rebuilding prohibition on transformers with less than 500 ppm PCBs could be extremely high. Comparing these potential costs to the relatively low threat to human health and the environment under the conditions required under the rule, EPA concludes that this activity should be authorized to continue because it does not pose an unreasonable risk to human health or the environment.

Unless there is reason to believe a transformer contains PCB (askarel) dielectric fluid or otherwise has 500 ppm PCB or greater, it may be assumed to have 50 to 500 ppm PCB. In practical terms, this means that mineral oil transformers need not be tested to determine whether they contain more than 500 ppm PCB. Available information indicates that virtually no mineral oil (non-askarel) dielectric fluid will be contaminated with PCBs above 500 ppm. Even if a small percentage of such fluid might contain somewhat more than 500 ppm PCB, EPA does not believe that the cost of testing needed to identify fluids with these slightly greater amounts is justified. Specifically, there are some 35 million transformers that would be subject to such a testing requirement. With each test costing between $50 and $100, the total cost of such testing would be as great as $3.5 billion. The additional health or environmental benefits that may result from requiring such testing and applying more stringent requirements in those few cases with more than 500 ppm would be extremely small compared to these testing costs.

For all practical purposes, testing of mineral oil dielectric fluid will only be used to determine whether the mixture contains less than 50 ppm PCB and is therefore exempt from the disposal requirements for mineral oil with over 50 ppm PCB. No testing is needed if the mineral oil will be burned in a high efficiency boiler or disposed of in any other way permitted for mineral oil contaminated with PCBs up to 500 ppm.

Many commentors questioned whether they would have to test the fluid from each transformer to determine the level of PCB contamination. Under the final rule, because such testing is optional, EPA anticipates that most persons will instead assume that the transformer contains between 50 ppm and 500 ppm PCB. If a person chooses to test, the final rule permits collection of mineral oil dielectric fluid into a single tank from more than one PCB-Contaminated Transformer. The mixture of fluids can then be sampled in a manner that reasonably represents the composite contents to determine PCB concentrations. (See preamble sections II.C and III.E above.) Draining a PCB

Transformer into such a tank is prohibited.

4. Rebuilding PCB Transformers

The transformer service industry and several transformer owners commented that PCB Transformer rebuilding should be permitted. The industry was particularly concerned with the economic impact on owners of specially designed transformers. Because of the time required to build a new transformer on special order, a prohibition of rebuilding PCB Transformers could significantly disrupt their operations if a transformer should unexpectedly fail. However, some transformer failures are so extensive that the transformer cannot be rebuilt. In these instances, the transformer owner must do without a transformer until it can be replaced with either a new or used transformer. Even when a failed transformer can be rebuilt, the transformer owner still must do without a transformer for the length of time required to rebuild the transformer. In both situations, the transformer owner must either operate at a reduced output or shut-down for some period of time. This may cause some economic hardships for owners of transformers; however, considering the substantial human exposure during rebuilding, the Agency believes that exposure to PCBs from rebuilding presents an unreasonable risk.

The other changes in the final rule, however, will reduce some of the economic impact on transformer users. The final rule permits the reclassification of PCB Transformers as PCB-Contaminated Transformers if they have been drained and refilled with non-PCB dielectric fluid and if they are tested and found to contain less than 500 ppm PCB after at least three months of in-service use. Three months is the minimum amount of time necessary to ensure that the PCBs trapped in the interior parts of the transformer leach out into the dielectric fluid. After reclassifying a PCB Transformer to a PCB-Contaminated Transformer in this way, an owner would be permitted to rebuild that transformer. This reclassification option reduces the risk of disruption of operations that could result from the prohibition of rebuilding PCB Transformers.

If a PCB Transformer owner takes advantage of the reclassification option described above and converts it to a PCB-Contaminated Transformer, the transformer could be rebuilt. The alternative of rebuilding has several economic advantages. In general, rebuilding will be cheaper than replacement. In addition, the production losses will probably be less if a failed transformer can be rebuilt rather than replaced. On the other hand, rebuilding PCB Transformers may result in a substantial increase in human and environmental PCB exposure. Considering these factors, EPA has decided to permit rebuilding but only of PCB-Contaminated Transformers. To rebuild the PCB Transformer the owner would first have to reduce the concentration of PCBs to less than 500 ppm according to the schedule contained in § 761.31(a)(5) and then rebuild.

5. Contents of Authorization

The previous discussion explains EPA's rationale for authorizing the servicing of transformers and the processing and distribution in commerce of PCBs for such servicing. The authorization, contained in § 761.31(a), is valid for persons who service their own transformers until July 1, 1984. Persons who process or distribute PCBs in conjunction with servicing transformers must be granted an exemption by EPA to continue these activities after July 1, 1979.

The authorization for servicing (including rebuilding) is subject to the following six conditions. First, regardless of its PCB concentration, dielectric fluid containing less than 500 ppm PCB that is mixed with fluids containing 500 ppm or greater PCB must not be used as dielectric fluid in any transformer. This condition is intended to prevent deliberate dilution of PCBs. Dielectric fluid from PCB-Contaminated Transformers may be assumed to have less than 500 ppm. Second, persons servicing or rebuilding PCB-Contaminated Transformers must use dielectric fluids that contain less than 500 ppm PCB. Third, any servicing (including rebuilding) of PCB Transformers that requires the removal of the transformer coil from the transformer casing is prohibited. Fourth, PCBs removed in servicing or rebuilding must be captured and either reused as dielectric fluid or disposed of in accordance with the requirements of Subpart B. Fifth, a PCB Transformer may be converted to a PCB-Contaminated Transformer, as described above. Sixth, any PCB dielectric fluid that is used to service or repair any PCB Transformer must be stored in accordance with the storage for disposal requirements of Annex III (§ 761.42 of this rule). This requirement is intended to minimize the possibility of spills and other accidental releases of PCBs in the environment as they are stored prior to use. Finally, any person who wishes to process and distribute in commerce PCBs for purposes of servicing transformers after July 1, 1979, may do so only if granted an exemption by EPA. Persons may continue to service transformers that they own without such an exemption.

B. Use and Servicing of Railroad Transformers

Transformers in approximately 1,000 electric railroad locomotives and self-powered cars operated in the northeastern United States by Amtrak, Conrail and five intracity transit authorities contain PCB fluid. PCB fluids are frequently spilled onto roadbeds when these transformers overheat and when rocks and debris damage these transformers. Workers and other persons near rail lines are potentially exposed to PCBs as a result of these spills. In addition, runoff from roadbeds probably contains increased PCB concentrations. PCBs are also volatilized during overheating and servicing. PCB exposure from servicing operations is similar to non-railroad transformer servicing and is laregely confined to service shops. Because of the human and environmental exposure to PCB that results from these activities, neither the use nor the servicing of railroad transformers is considered to be totally enclosed.

EPA considered various regulatory options for PCB-containing railroad transformers in implementing section 6(e) of TSCA. In proposing the rule, EPA assumed that the 1,000 railroad transformers could not be immediately replaced without an unacceptably severe curtailment of railroad service, especially in the Northeast Corridor, and attendant adverse economic and social consequences. The proposed rule would have authorized the use of the transformers if PCB concentrations were lowered to four percent in 15 months and then to 1,000 ppm in 36 months. In addition, the proposed authorization would have allowed servicing or rebuilding if non-PCB dielectric fluid was used. While the proposal would not have disrupted service, the affected railroad and transit companies would have had to invest an estimated $12.2 million over a three-year period to comply.

The affected parties criticized the timetable for lowering PCB concentrations. A recently initiated study of the safety of PCB-containing railroad transformers that have been refilled with non-PCB fluids is not expected to be completed until late 1979. The comments emphasized the importance of first assessing the feasibility of refilling with respect to transformer performance and potential hazards from explosion and fires as a result of the use of alternate fluids. Some comments also questioned whether a residual concentration of four percent PCB could be routinely achieved by refilling. These comments stated that a slightly higher level of six percent could be met on a routine basis. Other comments explained that, consistent with the Railroad Revitalization and Recovery Act of 1976, the Northeast Corridor railroads are changing the power supply specifications in mid-1981. Accordingly, some transformers are scheduled to be replaced and these comments suggested that to require the refilling of these transformers would impose a needless cost. As explained below, the 1981 date has changed.

The final rule takes these comments into account and authorizes continued use and servicing (including rebuilding) of these transformers as a non-totally enclosed use until July 1, 1984, subject to requirements that EPA believes will promote conversion to other types of transformers or dielectric fluids at the earliest feasible time. Persons may process or distribute PCBs in conjunction with servicing railroad transformers but must be granted an exemption by EPA to continue these activities after July 1, 1979. EPA is requiring that railroad transformers contain no more than six percent PCB by January 1, 1982, about 21 months later than proposed. This will give EPA more time to evaluate the safety of refilling these transformers with non-PCB fluid and will substantially reduce the costs of compliance. These transformers must either be replaced or be drained, flushed, and refilled with non-PCB fluid by that deadline. Before than, the use of PCB dielectric fluid for servicing (including rebuilding) railroad transformers is authorized. After that date, railroad transformers may only be serviced with fluid containing 6 percent PCBs or less.

By January 1, 1984, the concentration of PCBs in the transformers must not exceed 1,000 ppm. This is approximately 18 months later than proposed. EPA believes that the environmental and health risks that may be associated with continued use of PCB in these transformers over this period are outweighed by: (1) the yet undetermined safety risks of fire and explosion that may be associated with use of non-PCB fluid in refilled transformers; (2) the approximately $90 million cost that would be imposed if immediate conversion or replacement was required; and (3) the additional costs resulting from the disruption of critical transportation services. Therefore, EPA finds that this activity, as authorized, does not present an unreasonable risk.

Railroad transformers must be tested for PCBs immediately after the completion of any servicing conducted for the purpose of reducing the PCB concentration in the transformer's dielectric fluid and between one and two years after such servicing. Records of the results of this testing must be retained until January 1, 1991, which is five years after the last testing requirement of this rule.

EPA estimates that the total cost of complying with the final rule will be no more than $12.2 million over a five year period. Although comments indicated that some of the equipment will have been scrapped as a result of the planned change-over in mid-1981, the Department of Transportation has recently announced that this change-over will not occur until at least the Fall of 1983. The requirement to refill these transformers by January 1, 1982 provides at least 20 months of use before the change-over forces the older units out of service. Accordingly, these units could be in use for well over two years before phase-out would be required.

C. Use and Servicing of Mining Equipment

Under this authorization, PCBs may be used in mining equipment, including for purposes of servicing (including rebuilding) until January 1, 1982. However, rebuilding of continuous miner motors is permitted only until December 31, 1979. In addition, PCBs may be processed and distributed in commerce for purposes of servicing mining equipment in a manner other than a totally enclosed manner until July 1, 1979. After July 1, 1979, persons who process and distribute in commerce PCBs in conjunction with the servicing or use of mining equipment may do so only if granted an exemption by EPA to continue these activities.

There are two types of mining equipment that use PCBs as a coolant in electric motors: loaders and continuous miners. Although the manufacture of mining equipment using PCB fluids has ceased, approximately 517 such motors in loaders and 72 such motors for continuous miners are either in use or in existing inventories. PCBs may leak while the equipment is in service in underground mines or during servicing procedures, performed either in the shop or in the field. Exposure to PCBs during servicing primarily results from volatilization, spills, and direct human contact with PCBs when the inner parts of the motor are removed or rebuilt. Thus, the use and servicing of these motors are not totally enclosed activities.

To require replacement of these motors by the effective date of this rule would not be technically and economically feasible. There is only one company that currently converts PCB loader motors to air-cooled or other non-PCB motors, and PCB motors in continuous miners cannot be converted to non-PCB motors. Because of the location of the motor in continuous miners, this means that the entire machine has to be replaced. In both cases, lead time is essential to convert or replace the equipment. Prohibiting use of the equipment in the interim could result in a shut-down of approximately ten percent of the underground bituminous coal production in the United States. The impact of a prohibition of the use of PCB mining equipment can be significantly reduced by permitting more time for a phase-out. EPA believes that a phased approach is reasonable. As compared to an immediate prohibition, the risks to human health and the environment are only slightly increased, while the costs are substantially lower.

The final rule is essentially the same as proposed. To avoid the adverse consequences caused by an immediate use ban, EPA proposed a phase-out of these PCB motors. Different compliance schedules for loaders and continuous miners were proposed since they pose different problems. Because of the cutting head design, the motors on continuous miners cannot be rebuilt as non-PCB motors. The only feasible alternative is replacement of the entire continuous miner unit. Because of the lead time necessary to order and manufacture this type of equipment, EPA proposed to permit the rebuilding of PCB continuous miner motors until December 31, 1979. Rebuilding differs from servicing in that rebuilding involves removing the motor from the miner and disassembling the motor. Servicing is permitted until January 1, 1982. Service companies and others who want to process or distribute PCBs for rebuilding or servicing these motors after June 30, 1979, may do so only if granted an exemption by EPA to continue these activities. The use of continuous miners containing PCBs after January 1, 1982, is prohibited.

The PCB motors on loaders can be replaced with, or rebuilt as, air-cooled or other non-PCB motors. EPA is requiring that these motors be replaced or be rebuilt as air-cooled or other non-PCB motors when they are returned to service shops for maintenance, but, in no event, can PCB motors be used later than January 1, 1982. Rebuilding or replacement of existing PCB motors using normal maintenance patterns should take no longer than three years. Accordingly, use of these loaders is authorized until January 1, 1982.

Since normal maintenance practicies will permit an orderly rebuilding or replacement of motors with relatively modest costs, and with little additional exposure to PCBs, this gradual replacement requirement is a reasonable approach. However, no justification exists for permitting any PCB motors on loaders to remain in service after January 1, 1982, and therefore the use is prohibited after that date. Topping-off the motor fluid levels in the field with PCB fluids is also prohibited after January 1, 1982.

The authorization for mining equipment is essentially unchanged from the proposed rule. The estimated cost to owners of the equipment is estimated to be $2.6 to $4.3 million spread over 3 years.

D. Use in Heat Transfer Systems

Section 761.31(d) of the final rule authorizes the use of PCBs in heat transfer systems until July 1, 1984, subject to conditions regarding testing and reducing PCB concentrations. This authorization for use includes servicing of heat transfer systems. Heat transfer systems that are used in the manufacture or processing of any food, drug, cosmetic, or device, as defined in § 201 of the Federal Food, Drug, and Cosmetic Act, are authorized to use heat transfer fluid containing 50 ppm or greater PCB only until November 1, 1979.

PCBs were used as a heat transfer fluid in certain applications from 1962 to 1972. In the period from 1970 to 1972, approximately 90% of the heat transfer systems that used PCB fluid were refilled with non-PCB fluid. In spite of this refilling, most systems contain residual PCB concentrations. Heat transfer systems are, by and large, relatively, but not totally, enclosed systems and therefore their use of PCBs is not in a totally enclosed manner. The primary source of human and environmental exposure to PCBs from these systems comes from leaks in pump motor seals. However, good maintenance practices will minimize the quantity of fluids that may be lost. For most systems, the loss of PCB fluid is well controlled and the corresponding amount of top-off fluid added to these systems is very small.

An authorization for the use of heat transfer systems containing PCBs was not proposed because EPA had insufficient data to judge whether the use of these systems would pose an unreasonable risk. The preamble to the proposed rule solicited comments on this issue. According to the comments received, the PCB problem in heat transfer systems is generally one of residual PCB contamination of the non-PCB replacement fluids. In many respects, heat transfer systems are similar to hydraulic systems. For these reasons, the conditions of this authorization regarding the reduction of PCB concentrations are identical to those contained in the authorization for hydraulic systems: (1) any heat transfer system that ever contained PCB heat transfer fluid must be tested by October 1, 1979, and at least annually thereafter until the system reaches 50 ppm PCB; (2) any system that contains 50 ppm PCB or greater must be drained of the PCBs and refilled with non-PCB fluid (i.e., fluid containing less than 50 ppm PCB) within six months of the test showing the PCB concentration is 50 ppm or greater; (3) PCBs may not be added to heat transfer systems; and (4) records of the testing required under (1) must be retained for five years after the heat transfer system reaches 50 ppm PCB. The testing under (1) must be done at least three months after the most recent servicing conducted to reduce the PCB concentration. This time delay is to permit residual PCBs to leach out into the fluid before it is tested.

An exception to these requirements has been made for heat transfer systems used in the manufacture or processing of any food, drug, cosmetic, or device, as defined in section 201 of the Federal Food, Drug, and Cosmetic Act. These systems are authorized to use dielectric fluid containing 50 ppm or greater PCB only until November 1, 1979. After this date, these systems must contain less than 50 ppm PCB. This exception was made because, in the event of a heat transfer system rupture, PCBs would contaminate a product that would come in direct contact with humans, either through ingestion or through application to the skin. Unlike the rupture of a heat transfer system used in the manufacture of a product that is rarely in contact with humans, leakage of PCBs into a food, drug, cosmetic, or device provides a direct avenue for PCBs to enter the human body. Since the Food and Drug Administration required the removal of PCB heat transfer fluids from these systems several years ago, this restricted authorization should not present a problem to companies owning these systems.

EPA finds that this activity, as authorized, does not present an unreasonable risk to health or the environment. The total cost for the requirements described above is estimated to range from $12.2 to $17.8 million spread over three years.

E. Use in Hydraulic Systems

Under this authorization, PCBs may be used in hydraulic systems until July 1, 1984, subject to conditions regarding testing and reducing PCB concentrations. This authorization for use includes servicing of hydraulic systems. Processing and distribution in commerce for purposes of servicing, such as filtering, distilling, or otherwise reducing the concentration of PCBs in hydraulic systems, is authorized only until July 1, 1979. After July 1, 1979, persons are prohibited from processing and distributing in commerce PCBs for this purpose unless EPA grants them an exemption.

This authorization is necessary because a large number of die casting systems currently in use were once filled with PCB hydraulic fluid. Although this use of PCBs has been discontinued, equipment containing PCB hydraulic fluid is still in service. Some systems have been topped-off with non-PCB fluids, and others have been drained and flushed in an attempt to reduce PCB contamination. However, systems may still be contaminated with residual PCBs that either remain after flushing or are gradually released from interior surfaces. As a consequence, hydraulic systems can contain concentrations of PCB ranging from less than 10 ppm to thousands of parts per million PCB. These systems normally leak fluid, even when properly maintained. In addition, some of the fluid volatilizes as a result of the high operating temperatures. These losses result in PCB-contaminated water effluents as well as air emissions, both of which have contributed to existing levels of PCB contamination in the environment. Therefore, this use of PCBs is clearly not use in a totally enclosed manner.

Mandatory immediate removal of these systems from service to remove the PCBs could affect as many as one thousand companies and disrupt important sectors of industry, especially those using die castings. The extent of PCB exposure from these systems does not justify incurring such severe costs. On the other hand, the continued uncontrolled use of these systems would result in releases of substantial amounts of PCBs into the environment and cannot be allowed to continue. EPA proposed authorizing the continued servicing and use of PCB-contaminated hydraulic fluid in hydraulic die casting systems subject to certain conditions. One condition was that any system that contained 50 ppm or more PCB had to be drained and refilled with non-PCB fluid within one year. In addition, testing and servicing or replacement of the fluid was required at least every six months until the PCB concentration was consistently below 50 ppm.

The authorization in the final rule makes certain changes from the proposal. First, the proposed authorization covered only hydraulic die casting systems. Comments indicated that there are other types of hydraulic systems that used PCBs in high temperature environments such as in steel mills and foundries. Accordingly, the authorization has been extended to apply to the use of PCBs in all hydraulic systems.

Under the final rule, each hydraulic system must be tested no later than November 1, 1979. If the concentration of PCBs is found to be greater than 50 ppm, the whole system must be drained and refilled with non-PCB fluid within six months of the test. EPA anticipates that most of the PCBs will be removed during the initial refilling process. Subsequent draining and refilling may be necessary to remove residual PCBs. Under the final rule, persons who own hydraulic systems are required to test for the concentration of PCB annually instead of every six months as under the proposal. Comments indicated that removing a hydraulic system from use every six months would be disruptive. Most systems undergo repair or overhaul at least annually. The revised requirement would be consistent with these practices and, accordingly, result in substantial first year cost savings with little increase in PCB exposure. Records of this testing must be retained for five years after the hydraulic system reaches 50 ppm.

Many comments emphasized that requiring the draining of hundreds of gallons of fluids that may contain residual quantities of PCBs is not a cost-effective way to achieve reduction in PCB concentrations. Hydraulic systems are routinely topped-off with non-PCB hydraulic fluids. Comments argued that the addition of non-PCB fluids should effectively reduce the concentrations of PCBs. While topping-off is permitted for purposes of reducing the levels of PCBs at any time, EPA believes that an annual requirement to test and drain any fluids that contain more than 50 ppm is essential to reduce, as expeditiously as possible, the potential for PCB exposure. Although EPA does not believe that topping-off alone will reduce PCB concentrations quickly enough in all systems, many systems will be able to meet the requirements of the rule solely by topping-off. Allowing concentrations of PCBs above 50 ppm in these systems over time is not acceptable to EPA in terms of the significant risks to health and the environment associated with the leakage from these systems.

It is estimated that the costs to owners of affected hydraulic systems will total $14.6 to $25 million spread over the first two years, with insignificant costs in the subsequent years. These costs are similiar to the total cost of $19.7 million estimated in the proposal, but the final rule considered 1750 machines rather than the 1000 machines estimated in the proposal. This reduction in cost per machine is due to the annual, rather than semi-annual, testing requirement and more accurate cost information obtained as a result of the proposal. These costs are reasonable in light of the resulting reduction in human and environmental exposure to PCBs.

EPA finds that this activity, as authorized, does not present an unreasonable risk to health or the environment.

F. Use in Carbonless Copy Paper

Under this authorization, existing PCB carbonless copy paper may be used indefinitely. Prior to 1971, carbonless copy paper distributed by NCR Corporation was made with ink containing PCBs. There does not appear to be a way to distinguish PCB carbonless copy paper from non-PCB carbonless copy paper except perhaps by dates or other indications on unused inventories. A large portion of the PCB carbonless copy paper that has not been destroyed is probably in files. An enormous undertaking would be required of both business and government to purge existing files of PCB carbonless copy paper. Moreover, the amount of PCB on each sheet of carbonless copy paper is extremely small. In view of these practical considerations and because the potential PCB exposure and risks to human health or the environment are negligible, EPA has concluded that this activity does not present an unreasonable risk and is authorizing the continued use of existing PCB carbonless copy paper.

In the proposal, EPA limited this authorization to five years. However, EPA does not now believe that a method for inexpensively separating PCB from non-PCB carbonless copy paper will be developed in the near future. Accordingly, EPA is authorizing the use of existing PCB carbonless copy paper indefinitely.

G. Pigments

This rule authorizes the use of diarylide and phthalocyanine pigments containing more than 50 ppm PCB until January 1, 1982, and the processing and distribution in commerce of these pigments until July 1, 1979. After July 2, 1979, these pigments cannot be manufactured and after July 1, 1979, these pigments cannot be processed or distributed in commerce unless EPA grants exemptions for these activities.

Diarylide and phthalocyanine pigments contain PCBs as an impurity in concentrations ranging from several thousand parts per million to less then 50 ppm. Most of these pigments have PCB concentrations in the range of several hundred parts per million. These PCBs cannot easily be separated from the pigments because of the structural similarity of the PCBs to the pigments. Once manufactured, the pigments are mixed with other substances to form paints, inks, and a variety of other products. The PCB concentrations in these final products are less than 50 ppm.

Competitive pressure to market pigments with decreased PCB contamination is causing pigment manufacturers to change their processes. Comments indicate that within two years the industry will have made the changes necessary to reduce PCB contamination levels to less then 50 ppm.

In deciding whether to authorize pigment activities, EPA considered the relatively limited exposure and the economics associated with use of these pigments. The greatest potential for exposure is in the application of paints and inks using these pigments. These products contain far less than 50 ppm PCB because of the dilution that takes place when the pigment is mixed with the medium it is coloring. As a result, the health and environmental risks are not unreasonable. As discussed above, the industry is changing its processes to reduce the level of PCB contamination to below 50 ppm in the next two years. At the present time, these particular pigments are a major segment of the pigment market. For example, diarylide pigments form about 80% of the yellow pigment market. This ban will, therefore, affect a substantial number of pigment-related industries. However, the impact of the regulation of the pigment industry, as well as its customers in the paint and graphic arts industries, will be further considered during the rulemaking on manufacturing exemptions.

The potential costs of compliance are greatly reduced if the requirements are implemented over a few years. The increased health and environmental risk is relatively small. If exemptions are granted to permit more time for the conversion to alternative manufacturing processes, the cost of conversion will total $5.6 million. Based on these considerations, EPA has concluded that the processing and distribution in commerce until July 1, 1979, and the use of these pigments until January 1, 1982, will not present an unreasonable risk to health and the environment and should be permitted.

H. Use and Servicing of Electromagnets

As explained below, EPA considers the use of electromagnets containing PCBs to be used in a totally enclosed manner. Accordingly, this use does not require authorization. Processing and distribution in commerce of PCBs to service electromagnets is authorized, as explained below.

While no new PCB electromagnets have been manufactured since mid-1976, historically PCBs have been used in some electromagnets to reduce fire hazard. PCB electromagnets are used primarily over conveyor belts to remove tramp iron from non-magnetic commodities such as coal. PCB-containing electromagnets still in use are found in enclosed areas such as coal mines, coal preparation plants, and coal-fired generating stations where there is a danger of producing explosive dusts. PCB electromagnets may also be used over conveyor belts in grain handling systems, but EPA does not have information on specific locations at this time.

Electromagnets are similar to transformers in construction. An electromagnet is a completely welded piece of equipment. Any leakage would be the result of deteriorating equipment or accidental damage rather than design characteristics. EPA has concluded that use of PCBs in electromagnets under normal circumstances is a use in a totally enclosed manner. For coal-handling systems, if leakage does occur, there will be negligible risks as the coal is handled automatically and eventually burned in combustion devices capable of destoying almost all of the PCBs. While EPA is not certain that electromagnets containing PCBs are currently in use over grain conveyors, accidental leakage in such situations may contaminate food supplies and thus pose a threat to human health. For these reasons, EPA will consider use of electromagnets over grain conveyors that leak to be a violation of this rule as a non-totally enclosed use of PCBs. In addition, EPA is notifying the U.S. Department of Agriculture and the Food and Drug Administration of this potential problem.

The servicing of PCB electromagnets is similar to servicing of PCB Transformers. Accordingly, this rule authorizes the same type of servicing of PCB electromagnets with PCB dielectric fluid. As in the case of PCB Transformers, any servicing (including rebuilding) that requires the removal of the coil from the casing is prohibited. Most of the discussion of the servicing of PCB Transformers in section IX.A of this preamble pertains to servicing PCB electromagnets. EPA has similarily concluded that this servicing, as long as it does not include removal of the coil from the casing, will not present an unreasonable risk to health or the environment. Because of limited information, EPA was unable to ascertain the costs of not granting such authorization.

I. Use in Natural Gas Pipeline Compressors

The final rule authorizes the use, including servicing, of PCBs in natural gas pipeline compressors until May 1, 1980. An authorization was not proposed for this use of PCBs because EPA had virtually no knowledge of it. Several comments on the proposed rule indicate that compressors used in natural gas pipelines contain residual PCB concentrations greater than 50 ppm. In general, these systems were drained of high concentration PCB fluid several years ago, thereby removing most of the PCBs. This authorization will allow these compressors to be drained and refilled with non-PCB fluid to further reduce the PCB concentration until it is below 50 ppm. The authorization is effective until May 1, 1980, giving persons time to work on the systems to reduce the concentration of PCBs during the summer months when demand for natural gas is lower. Use and servicing of these compressors are not a totally enclosed activity because of limited environmental exposure that may occur during servicing and use.

An immediate use prohibition could have a serious effect on natural gas distribution. Permitting more than a half a year to complete the draining and refilling significantly reduces costs and disruptions in service while causing little or no increase in exposure to PCBs. The total cost of these decontamination operations is $200,000. Because of the small quantities and low concentrations of PCBs involved, EPA believes that this authorization will not result in exposure to PCBs that presents an unreasonable risk to health or the environment.

J. Use of Small Quantities for Research and Development

EPA is authorizing the use of PCBs in "small quantities for research and development", as defined in § 761.12(ee), until July 1, 1984. Processing and distribution in commerce of PCBs for this purpose is authorized until July 1, 1979. After July 2, 1979, PCBs cannot be manufactured for this use, and after July 1, 1979, they cannot be processed or distributed in commerce, unless persons interested in continuing these activities have been granted an exemption.

Because of the importance of on-going research on the effects of PCBs and the need to have reference standards for analytical purposes, EPA believes that the extremely limited exposures associated with these activities do not present an unreasonable risk to health and the environment. The term "Small Quantities for Research and Development" is defined very narrowly. Specifically, PCBs must be contained in hermetically-sealed, five milliliter containers. EPA believes this constraint is sufficient precaution against the risks of human or environmental exposure to justify such use in light of the possible benefits of continued research. The proposed rule would have excluded these activities from the prohibitions in § 761.30; however, EPA believes it is more appropriate to authorize (and if appropriate exempt) these activities.

K. Use in Microscopy

EPA is authorizing the use of PCBs as a mounting medium for microscopic slides until July 1, 1984, and the processing and distribution in commerce of PCBs for this purpose until July 1, 1979. After July 1, 1979, persons who want to continue processing and distribution in commerce activities must be granted an exemption by EPA. Persons who want to manufacture PCBs for this use after July 2, 1979, must also be granted an exemption by EPA.

When PCBs are used as a mounting medium for slides, extemely small quantities are used on each slide. This use is particularly important to scientists who need to preserve, for future reference, a microscope particle. PCBs are also used in air pollution and criminology labs for microscopic particle identification and they play a vital role in the study and conservation of art and historic objects through use of microscopic slides. In mounting, a particle is placed in a PCB medium and covered with a cover slip, usually for permanent reference. No substitutes with the necessary physical properties exist for this use.

Because of the small quantities of PCBs used at any one time and the careful nature of laboratory work, exposure to PCBs used as a mounting medium is minimal. Because of the substantial benefits of this use of PCBs and the very limited risks involved, EPA believes that this activity will not present an unreasonable risk and that it is appropriate to authorize this use of PCBs.

X. PCB Activities Not Authorized by This Rule

A. Manufacture of PCB Capacitors

PCBs have been used as a dielectric fluid in alternating current capacitors manufactured in the United States from the mid-1930's through the mid-1970's. Although the manufacture of PCB Capacitors is considered to be "processing" of PCBs and could continue under section 6(e)(3) until July 1, 1979, the activity is not totally enclosed and accordingly is prohibited under section 6(e)(2) after July 2, 1979.

In the past, manufacture of PCB Capacitors has been a major source of PCB release into the environment. For example, the upper reaches of the Hudson River are closed to fishing because of PCB contamination caused by capacitor manufacturing. The Support Document to the final rule (Chapter II) discusses this and other examples of environmental damage caused by this activity. In addition, there are substitutes available as discussed in Chapter III of the Support Document to the final rule. For these reasons, EPA has determined that the continued manufacture of PCB Capacitors presents an unreasonable risk to human beings and the environment and has not authorized it under section 6(e)(2). It is EPA's understanding that no company is planning to manufacture PCB Capacitors after the effective date of this rule.

B. Manufacture of PCB Transformers

The use of PCBs as a transformer dielectric fluid dates back to the 1930's. The manufacture of PCB Transformers is also considered to be "processing" PCBs under TSCA but is not a totally enclosed activity. Under section 6(e)(2), it may not continue after July 2, 1979. Significant quantities of PCB may enter the environment during the manufacture of PCB Transformers. Production of PCB Transformers has been responsible for major river damage, notably the Coosa River in Northwest Georgia. Because of the environmental and human exposure to PCBs that occurs in the manufacture of these transformers and because of the availability of substitutes, EPA has determined that the manufacture of PCB Transformers presents an unreasonable risk and, therefore, has not authorized this activity. It is EPA's understanding that the manufacture of PCB Transformers in the United States ceased in 1977.

C. Other PCB Activities

All manufacturing of PCBs is prohibited after July 2, 1979. Persons who have submitted a petition for a manufacturing exemption in accordance with the November 1, 1978 rulemaking procedures (43 FR 50905) will not be subject to this ban until EPA acts upon their petitions (see 44 FR 108, January 2, 1979).

All processing, distribution in commerce, and use of PCBs in other than a totally enclosed manner is prohibited after July 2, 1979, unless specifically authorized in § 761.31 of this rule.

XI. Manufacturing, Processing, or Distribution in Commerce of PCBs for Export

Section 12(a) of TSCA states, in general, that no provision of TSCA shall apply to the manufacture, processing, or distribution in commerce of a chemical intended solely for export from the United States. However, if the Administrator finds that the manufacture, processing, or distribution in commerce of a chemical substance solely for export presents an unreasonable risk to health or the environment in the United States, those activities may be regulated under TSCA.

It is the clear intent of TSCA to minimize the addition of PCBs to the environment of the United States. The extreme persistence of this substance and the ease with which it is transported has made it a global problem. There is considerable evidence of PCB contamination that is far from any known source (see Chapter II of the Final Support Document). Therefore, PCBs used outside the United States can cause PCB contamination of this country. Moreover, manufacturing, processing, and distribution in commerce of PCBs in this country for purposes of export is likely to cause significant release of PCBs in this country through air and water emissions, leaks and spills, and other means. Instances of severe PCB releases from manufacturing, processing, transportation, and other activities involving PCBs are well documented. Because of these factors, EPA has determined that the manufacture, processing, and distribution in commerce of PCBs for export constitutes an unreasonable risk to health and the environment in the United States.

The final rule prohibits: (1) any manufacture of PCBs for export after the effective date of this rule; and (2) the non-totally enclosed processing and distribution in commerce of PCBs for export as of the effective date of this rule; and (3) any processing or distribution in commerce of PCBs for export after July 1, 1979, except solely for purposes of disposal in accordance with § 761.10. These prohibitions are essentially the same as proposed. Like domestic manufacturers, processors, and distributors in commerce, persons wishing to manufacture, process, or distribute in commerce PCBs or PCB Items solely for export may petition EPA for an exemption as discussed in the preamble section VIII.A above.

In addition, section 12(b)(2) of TSCA requires any person who exports or intends to export a chemical substance or mixture for which a rule has been proposed under section 6 to notify the Administrator of such export or intent to export. This requirement applies to any export of PCBs except the export of wastes which require a special report as discussed in VI.B.2 above. The requirement does not apply to the export of PCB Equipment, although the export of such equipment requires an exemption after July 1, 1979. The export of PCBs in small quantities for research and development (as defined in § 761.2(ee)), for example, does require notice to EPA.

Interim procedures regarding this requirement can be found at 43 FR 24818 (June 7, 1978). In summary, these procedures require that notices be submitted for the exports of all PCBs and PCB Items (except PCB Equipment), and the following information is to be included:

(a) The name and address of the exporter; (b) the dates of each shipment or intended shipment; (c) the country (countries) of import; and (d) a statement that notice is being submitted pursuant to Section 12(b) and 40 CFR Part 761.

Notices shall be sent to the Document Control Officer, (TS-793), Office of Toxic Substances, U.S. Environmental Protection Agency, 401 M Street S.W., Washington, DC 20460.

XII. Test Procedures for PCB

Test procedures for determining the PCB concentration in various media were not included in the proposed PCB Ban Rule. A number of comments on the rule suggested that EPA provide additional information on test methods.

EPA has been involved in the development of test methods for several media and has made much of this information available to the public. Specifically, test procedures have been made available for determining PCB concentrations in air, soil, water, and sediments using an American Society of Testing and Materials method (ASTM D 3304) and in industrial effluents using EPA methods (primarily for low concentration of PCB in water) (40 CFR 136). In addition, an interim guidance package containing two test procedures (one for spills in soil and one for water) was made available to EPA Regional Offices in February 1978 for distribution to the public. In the final step of analyzing the sample, all of these procedures rely on a gas chromatograph with an electron capture detector. The primary differences between the procedures are in the methods used to separate the water-soluble fraction from the organic-soluble fraction. The latter fraction contains the PCBs and is the portion used in the gas chromatograph.

Several comments were critical that EPA did not have more specific test procedures for PCBs, in particular for mineral oil dielectric fluid and pigments. The contamination of mineral oil dielectric fluid with PCBs is a major subject of this rule and the problem affects a large number of utilities and industries. EPA has experience in the analysis of contaminated oils and has included a test procedure (described below) in an additional guidance package that will be distributed to EPA Regional Offices. Pigments represent a different type of analytical problem. Pigments are a complex analytical media, and analytical chemists in that industry who have the most knowledge on resolving analytical chemistry problems with that substance have developed techniques to quantify PCBs in pigments.

Pigment manufacturers have developed thus far several test procedures and are currently working to validate one of them. With respect to other substances or mixtures that may be contaminated with PCBs, EPA also presumes that persons who manufacture such substances have the expertise to analyze their product and are best equipped to determine whether, and to what extent, their product is contaminated with PCB.

EPA will make use of industry-developed test procedures in conducting surveys or inspections and will use data from such tests in enforcement actions where appropriate. EPA may also examine industry-developed test procedures and make modifications, if possible, that would increase the accuracy and sensitivity of the test. Such modifications will be made publicly available. Persons who manufacture or process chemicals in a manner that could result in the production of PCBs as a primary product, impurity, intermediate, precursor, or byproduct are responsible for determining whether PCBs have been produced. They will have to conduct tests using good analytical chemistry and investigate ways to improve their ability to detect and quantify PCBs.

For the testing of PCB contaminated oils, EPA uses the following analytical procedure which consists of three successive clean-up steps: at least one run through an activated silica gel column, a run through an activated basic alumina column, and a final run through an activated silica gel column followed by analysis on the gas chromatograph equipped with an electron capture detector. This procedure can be used on any waste oil. For a mineral oil dielectric fluid that is relatively clean, an alternative procedure that would yield a less accurate PCB concentration with less effort and lower cost would be to substitute a liquid-liquid clean-up step for the column clean-up. This clean-up involves mixing the oil sample with concentrated sulfuric acid and then draining of the oil fraction. The oil fraction is then run through the gas chromatograph. This clean-up step removes oxidized organic material, thiophenes, and moisture from the oil sample. This alternative is not as accurate as the column clean-up method, but for "clean" oils, it provides a less expensive, more expedient test procedure.

EPA recognizes that these procedures are subject to experimental errors and that any procedure, no matter how simple, can be run improperly. However, persons who are subject to this rule will be expected to exercise good judgment on testing decisions. For example, if, in the case of the two procedures described above for PCB contaminated oils, the more rigorous procedure may yield results of ±1 ppm PCB while the quicker procedure may yield results of ±15 ppm PCB (these estimates of error are only used as illustrative examples and are not based on actual test data) and a sample is tested by the more accurate procedure and results in a value of 30 ppm PCB, then a person could be reasonably certain that the sample falls into the less than 50 ppm category. However, if using the less accurate procedure results in a value of 45 ppm, then a person has two choices: either treat the sample as a greater than 50 ppm PCB or test the sample again with the more accurate test procedure. In this case, EPA will not consider it to be good judgment to assume that the sample has less than 50 ppm PCB because the experimental error of the procedure overlaps the cut-off point.

XIII. Compliance and Enforcement

EPA will devote a major enforcement effort to ensure compliance with the requirements of these regulations. EPA intends to take vigorous action to assure that all facilities which manufacture, process, distribute in commerce, or use PCBs, handle and dispose of PCBs properly. While EPA will be reasonable in interpreting the application of these requirements, persons who are or may be subject to these regulations should be aware that failure to properly comply with these regulations may subject them to serious civil and criminal sanctions.

Section 16 of TSCA authorizes the imposition of a civil penalty of up to $25,000 for each violation of these rules. Each day a violation continues constitutes a separate violation for the purpose of § 16. A knowing or willful violation of these rules may, in addition to any civil penalty, lead to the imposition of criminal penalties in the amount of up to $25,000 for each day of violation and imprisonment for up to one year. In addition, EPA has the authority under section 17 of TSCA to compel persons to take actions to rectify or clean up after violations.

EPA will seek stringent penalties in any situation in which significant dispersion of PCBs occurs due to a violation. Civil penalties will be scaled according to the severity of the violation. Facilities that violate approval, exemption, or authorization conditions shall also be subject to penalties under §§ 15 and 16 of TSCA, as well as the revocation of their approval, exemption or authorization. In addition, in these situations, EPA will use TSCA section 17 injunctive and seizure powers to reduce or eliminate the risks of a PCB regulation violation. For violations which risk no direct dispersion of PCBs, EPA is less likely to seek severe penalties. Facilities may be simply put on notice of certain violations and compelled to rectify any observed violations.

"Any person" who violates these regulations will be subject to an enforcement action. This includes individuals, such as corporate officials

Reproduced from best available copy.

and employees, as well as violating companies. EPA takes the position that persons may not contract away their responsibility or liability for violation of these rules, i.e. a PCB user who contracts for PCB disposal or storage with a company that he knows or should know has inadequate disposal or storage facilities, may himself be the subject of an enforcement action. This policy applies to all remedies EPA may seek for a violation.

EPA will be directing its resources to the discovery of significant instances of exposures of PCBs to the environment and developing accurate information depicting the flow of PCBs to proper disposal. Using information developed during inspections and using the records required to be kept under § 761.45, EPA will be able to focus its efforts upon areas which show the greatest potential for violation.

XIV. Relationship of PCB Disposal Under TSCA to Hazardous Waste Disposal Under RCRA

The disposal requirements of this rule specify the actions that must be taken when disposing of PCBs.

In addition, the rule contains Annexes that delineate specifications for disposal facilities that are to be used for the disposal of PCBs. These facilities are also addressed in the hazardous waste disposal rules proposed under the Resource Conservation and Recovery Act (RCRA) on December 18, 1978 (43 FR 58946). Several options for integrating the PCB rule with the RCRA rules are discussed in the preamble to the RCRA rules at 43 FR 58993 and comments were requested on the alternatives. Prior to the promulgation of the RCRA rules, EPA will resolve the differences between these two rules. Because of the special disposal problems presented by PCBs, EPA could choose to continue special provisions for the disposal of PCBs. EPA's decision will be announced when the rules under RCRA are promulgated.

XV. Summary of Economic Consequences

Section 6(e) of TSCA prohibits (1) the use of PCBs in a non-totally enclosed manner unless the use is authorized and (2) all manufacture, processing, and distribution in commerce of PCBs unless they are otherwise exempted by the Administrator. These authorizations and exemptions, however, are discretionary and can be granted only upon a finding that a particular PCB activity does not pose an unreasonable risk to health or the environment.

The impacts of both the statute and the regulation have been assessed and are discussed below. Additional information on these impacts is contained in *PCB Manufacturing, Processing, Distribution in Commerce, and Use Ban Regulation: Economic Impact Analysis* (the Versar Report) which can be obtained from the Industry Assistance Office of the Office of Toxic Substances upon request (see the beginning of this preamble for the address and telephone number).

A. Impact of the Statute

It was the clear intent of Congress, as expressed in Section 6(e) and in the pertinent legislative history, that the manufacture of PCBs should cease. Since no more PCBs will be made (unless exemptions are granted), it follows that there can be no future manufacturing of PCB Transformers or Capacitors. Consequently, the costs attributed to the cessation of the manufacture of PCB chemical substance, PCB Transformers, and PCB Capacitors are considered impacts of the statute, not of the regulation.

These costs are attributable to the statute and not to the regulation and include $12–$30 million per year in increased capacitor costs that will be borne by utility and industrial users. This results from an across-the-board increase in capacitor prices of 10–20 percent due to the higher costs of PCB substitutes. This cost will continue indefinitely, unless the cost of these substitutes falls. Purchasers of Non-PCB Transformers will incur increased costs of up to $10 million per year, depending on the particular substitute dielectric fluid selected. This cost will also continue indefinitely. These increased costs of transformers and capacitors will be passed on through a minimal increase in the cost of electricity to consumer and industrial users.

B. Impact of the Rule

The total first year cost of this rule is expected to range between $58 million and $105 million. By 1985 the annual costs will drop to between $30 million and $37 million. Annual costs should continue to diminish subsequent to 1985 as the use of PCBs is discontinued.

The largest annual economic impact of this regulation may result from the prohibition of the use of waste oil containing any detectable amount of PCB for dust control on roads. Since most waste oil contains very low PCB levels, as much as 300,000,000 gallons of waste oil per year will be diverted from this use. Highway departments and private road owners will have to use substitute products which could cost them as much as $31.7 million per year for the first several years of this rule. Note that the manufacturers of substitute products assert that use of their products will substantially reduce road maintenance costs when compared to the use of waste oil for road oiling and that such a reduction would directly reduce the net cost of the rule. However, EPA is not able to verify the potential savings involved.

The ban on rebuilding transformers which contain dielectric fluid with a 500 ppm or greater PCB concentration will cost the owners of these transformers approximately $12 million in the first year of the rule. This annual cost will be gradually reduced over a period of 30 to 40 years as the transformers are replaced. Included in the $12 million estimate is an estimated $2.4 million in costs attributed to a projected increase in down-time. In other words, when a power delivery is interrupted by an electrical failure of a PCB Transformer the rule's effective requirement that the failed PCB Transformer be replaced by a new, rather than a rebuilt transformer, will cause a longer than normal interruption. About two thirds of these transformers are owned by commercial and industrial firms and the remainder by utilities. The impact of this rule with respect to transformers is expected to have a negligible effect on the cost of electricity, and no significant impact on non-utility owners.

The cost of disposing of PCB-contaminated mineral oil will be significantly less than under the proposed rule. The final rule modifies the proposed requirement and allows disposal in high efficiency boilers. It is expected that the annual costs under the changed disposal requirements will be between $3.2 million and $17.0 million. Included in both the low and the high estimates is an estimated annual disposal cost of $11.1 million which could be incurred by disposers of contaminated mineral oil who do not own high efficiency boilers. In addition, the owners of high efficiency boilers will likely incur some capital costs in the first year of the rule in order to take advantage of the new provisions.

Seven railroad and transit companies which are affected by this rule will incur total additional operating costs of $12.2 million. These costs will be spread over the next five years. The costs will be incurred because of refilling of PCB-Containing Transformers used on locomotives and self-powered cars with substitute non-PCB fluid, and in periodically removing residual PCB contamination from the new fluid. Since only electrically-powered units are involved, the costs will be borne solely by railroads and public transit authorities in the Northeast. These companies are in financial trouble; however, funding may be available through Federal subsidies.

Underground mining equipment will be impacted because of an older design electric motor which used PCBs as a coolant. The use of these motors will be banned as of January 1, 1982, and the total cost to users of PCB mining equipment will be $2.6 to $4.2 million. Since the ban is designed to allow a phase-out of the use of the equipment through conversion or obsolescence, it should cause no interruption of coal production. These costs are not expected to cause significant problems for the equipment owners.

Owners of hydraulic systems with PCB-containing hydraulic fluid will have to test, drain, and refill these systems periodically. As many as 1,750 systems including metal die casting and foundry equipment are believed to be affected by the rule and costs for the initial two years are expected to total between $14.6 and $25 million; costs for subsequent years should be insignificant.

Owners of heat transfer systems with PCB-containing heat transfer fluid will also have to test, drain, and refill these systems periodically. As many as 600 systems are believed to be affected by the rule, and costs for the first three years are expected to total between $12.2 and $17.8 million; cost for subsequent years should be insignificant.

Threre are a number of commercial chemical processes which produce PCBs as an unintentional byproduct in concentrations over 50 ppm. For instance, the presence of PCBs (in excess of 50 ppm) in phthalocyanine and diarylide yellow pigments has been detected. It is estimated that the pigment industry can change its production process within two years at a cost of approximately $5.8 million so that unintentional PCB production will no longer be a problem. Little is known about the cost or feasibility of eliminating PCB contamination from other chemical production processes. However, since all of these problems of PCB-contamination in the production of pigments and other chemical products will be dealt with on a case-by-case basis in exemption rulemakings, the Agency will be able to assess these economic impacts at that time.

Also, this regulation could potentially have a very costly impact on sellers of electrical equipment containing PCB Capacitors if EPA does not provide exemptions from the prohibition on distribution in commerce of PCB Equipment. These costs will be carefully considered in the separate rulemaking concerning exemptions to the July 1, 1979, distribution in commerce ban.

Several other very minor impacts which will be incurred only during 1978 have been identified. These impacts include owners of natural gas pipeline pump compressors who are expected to spend $200,000 in 1979 to remove PCB fluid from those compressors. The ban on rebuilding the approximately 200 electromagnets containing PCBs is expected to cost users $100,000 annually and have a total cost of less than $1 million.

Most of the costs discussed above result from requirements that are part of the authorizations to permit continued use of mixtures, articles and equipment containing PCBs in a manner protective of health and the environment. If these authorizations were not promulgated, the cost and economic impact on the affected industries could be considerably greater than the costs discussed above. EPA has carefully examined the costs of this rule and does not expect any severe economic or social impacts.

Dated: April 16, 1979.

Douglas M. Costle,
Administrator.

PCB Record

Official Record of Rulemaking-PCB Ban Regulations [1]

Section 19(a)(3) of TSCA defines the term "rulemaking record" for purposes of judicial review as follows:

(A) The rule being reviewed under this section;

(B) In the case of a rule under section 4(a), the finding required by such section, in the case of a rule under section 5(b)(4), the finding required by such section, in the case of a rule under section 6(a), the finding required by section 5(f) or 6(a), as the case may be, in the case of a rule under section 6(a), the statement required by section 6(c)(1), and in the case of a rule under section 6(e), the findings required by paragraph 2(B) or 3(B) of such section, as the case may be;

(C) Any transcript required to be made of oral presentations made in proceedings for the promulgation of such rule;

(D) Any written submission of interested parties respecting the promulgation of such rule; and

(E) Any other information which the Administrator considers to be relevant to such rule and which the Administrator identified, on or before the date of the promulgation of such rule, in a notice published in the **Federal Register.**

In accordance with the requirements of section 19(a)(3)(E) quoted above, EPA is publishing the following list of documents constituting the record of this rulemaking. This list does not include public comments, the transcript of the rulemaking hearing, or submissions made at the rulemaking hearing or in connection with it. These documents are exempt from **Federal Register** listing under section 19(a)(3). A full list of these materials will be available on request from the Record and Hearing Clerk.

Federal Register Notices Pertaining to This Rule

43 FR 24802, June 7, 1978. USEPA. "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Bans Proposed Regulation."

42 FR 32555, June 27, 1977. USEPA. "Polychlorinated Biphenyls: Open Public Meeting; Solicitation of Comments."

42 FR 61259, December 2, 1977. USEPA. "Procedures for Rulemaking Under Section 6 of the Toxic Substances Control Act."

42 FR 65264, December 30, 1977. USEPA. "Polychlorinated Biphenyls: Policy for Implementation of Section 6(e)(2) of the Toxic Substances Control Act (TSCA)."

43 FR 38057, August 25, 1978. USEPA. "Polychlorinated Biphenyls: Manufacturing, Processing, Distribution in Commerce, and Use Bans; Clarification."

43 FR 43048, September 22, 1978. USEPA. "Polychlorinated Biphenyls: Manufacturing, Processing, Distribution in Commerce, and Use Bans: Extention of Reply Comments."

44 FR 108, January 2, 1979. USEPA. "Polychlorinated Biphenyls: Policy for Implementation and Enforcement of Sections 6(e)(2) and 6(e)(3) of the Toxic Substances Control Act (TSCA)."

Support Documents

USEPA, OTS, "*PCB Manufacturing, Processing, Distribution in Commerce and Use-Ban Regulation-Proposed Action-Support Document."/Voluntary Draft Environmental Impact Statement, Environmental Protection Agency (40 CFR Part 761).* May 1978.

USEPA, OTS, *Environmental Protection Agency Support Document/Voluntary Environmental Impact Statement for Polychlorinated Biphenyls (PCB) Manufacturing, Processing, Distribution in Commerce and Use Ban Regulation.* March 1979.

USEPA, OPM. *Microeconomic Impacts of the Proposed 'PCB Ban Regulations': May, 1978.* EPA 560/6-77-035. Versar, Inc. Contract No. 68-01-4771.

USEPA, OPM. *PCB Manufacturing, Processing, Distribution in Commerce, and Use Ban Regulation: Economic Impact Analysis.* March 30, 1979. EPA-230-12/79-006. Versar, Inc. Contract No. 68-01-4771.

---

[1] The official record of rulemaking for the Polychlorinated Biphenyls Marking and Disposal Regulation (43 FR 7150, February 17, 1978) is part of the record of this rulemaking. The official record of rulemaking for the PCB ban regulation also includes the official record for the Administrator's promulgation of toxic pollutant effluent standards for PCBs under section 307(a) of the Clean Water Act (42 FR 6532-6555, February 2, 1977).

Reproduced from best available copy.

Other Information

Other "Federal Register" Notices

41 FR 7552, February 19, 1976. "Velsicol Chemical Company et al., Consolidated Heptachlor/Chlordane Hearing."

41 FR 21402, May 25, 1976. "Health Risk and Economic Impact Assessments of Suspected Carcinogens: Interim Procedures and Guidelines."

42 FR 55026, October 12, 1977. "TSCA Interagency Testing Committee-Initial Report to the Administrator, EPA."

43 FR 7150, February 17, 1978. "Polychlorinated Biphenyls (PCBs) Disposal & Marking Final Regulation."

43 FR 33918, August 2, 1978. "Addendum to Preamble and Corrections to Final Rule (PCBs),"

USEPA-Non "Federal Register" Statements

Region IV. News release in reference to fishing in Lake Hartwell and Twelve Mile Creek in Pickins County, South Carolina. Dated about September 10, 1976.

Statement of Honorable Russell E. Train, Administrator, EPA, before the Subcommittee on Fisheries and Wildlife Conservation and the Environment, Committee on Merchant Marine and Fisheries, House of Representatives. January 28, 1976.

Remarks by the Honorable Russell E. Train, Administrator, EPA prepared for delivery at the National Conference on PCBs, Chicago, Illinois, Wednesday, November 19, 1975, 10 a.m. Eastern Standard Time. Environmental Protection: *Rx for Public Health.*

Region I *News Release:* September 14, 1976.

USEPA, OTS, CAD. *Proposed PCB Ban Rule Summary.* April 30, 1978.

USEPA, Press Office. *EPA Proposed Rule To Ban Polychlorinated Biphenyls (PCBs).* June 7, 1978.

Pre-Proposal Publicly Announced Meetings

USEPA. *Transcript of Proceedings: Public Meeting on the Ban of Polychlorinated Biphenyls.* Washington, D.C., July 15, 1977.

USEPA. *Transcript of Proceedings in the Special Meeting of U.S. Environmental Protection Agency, Region V-Chicago, ILL.*, July 18, 1978.

Documents Submitted at the July 19, 1977 Public Meeting

Statement on Retrofilling Made at Public Meeting on the Implementation of the Environmental Protection Agency's Proposed PCB Ban. July 19, 1977. Dow Corning Corp.

Presentation to Environmental Protection Agency. Public Meeting-July 19, 1977. Joy Manufacturers.

Communications

These include, but are not limited to, intragovernmental memoranda, letters, and memoranda of telephone conversations.

Reports

1. *Alvares, Alvito P. "Alterations in Drug Metabolism in Workers Exposed to Polychlorinated Biphenyls." *Clinical Pharmacology and Therapeutics* 22:2 (undated): 140–146.

2. *Bahn, Anita K. *Report on Paulsboro, N.J. Mobil Oil Plant Study.* Philadelphia: Department of Community Medicine, University of Pa., School of Medicine, (April 27, 1976).

3. *Bartha, Richard, and Pramer, David. "Pesticide Transformation to Aniline and Azo Compounds in Soil." *Science* 156 (June 23, 1976): 1617–1618.

4. *Berlin, Maths, Gage, John, and Holm, Stina. "Distribution and Metabolism of 2,4,5,2',5-Pentachlorobiphenyl." *Archives of Environmental Health* 30 (March 1975): 141–147.

5. *Bidleman, T. F., and Olney, C. E. "Chlorinated Hydrocarbons in the Sargasso Sea Atmosphere and Surface Water." *Science* 183 (October 1, 1973): 516–518.

6. *Blau, G. E., and Neely, W. Brock. "Mathematical Model Building with an Application to Determine the Distribution of Dursban Insecticide Added to a Simulated Ecosystem." *Adv. Ecology Res.* 2 (1975): 133–163.

7. *Bowes, G. W., and Jonkel, Charles J. "Presence and Distribution of Polychlorinated Biphenyls (PCB) in Arctic and Subarctic Marine Food Chains." *J. Fish. Res. Bd. Cem.* 32:11 (1975): 2111–2123.

8. *Canada, Environment Canada. *Background to the Regulation of Polychlorinated Biphenyls (PCB) in Canada.* Ottawa: Task Force on PCB, Technical Report 76:1 (April 1, 1976): 41–42.

9. *Denbigh, Kenneth. *The Principles of Chemical Equilibrium with Applications in Chemistry and Chemical Engineering.* (Cambridge: University Press, 1955), 268–272.

10. Dow Corning Corporation. *A Material Balance Study of Polychlorinated Biphenyls in Lake Michigan.* Midland, MI: Environmental Sciences Research, by Neely, W. Brock, *The Science of the Total Environment 7* (1977): 117–129.

11. *Dow Corning Corp. *Removal of PCBs from Dow Corning 561 Silicone Transformer Liquid by Charcoal Filtration.* Midland, MI: Joint Project of Dow Corning, Transformer Consultants, DC Filter and Chemical, Inc., (undated).

12. *EG&G. *Fathead Minnow Egg and Fry Study, Summary of.* Wareham, MA: Bionamics Aquatic Toxicology Laboratory, (August 26, 1977).

13. **Environmental Defense Fund v. Environmental Protection Agency,* 510 F2d 1292, 1298 (DC Cir. 1972).

14. **Environmental Defense Fund v. Environmental Protection Agency,* 548 F2d 998, 1006 (DC Cir. 1976).

15. *Environmental Defense Fund (EDF) and New York Public Interest Research Group, Inc. (PIRG). *Troubled Waters: Toxic Chemicals in the Hudson River* IV (1977): 6–11.

15.a Florida Power and Light Company. Report on PCB Sampling Program for Florida Power and Light Company. Miami: Edward E. Clark, Engineers-Scientists, (August 4, 1978). Submitted to Jeffrey G. Miller, USEPA, DAA for Water Enforcement by Robert E. Uhrig, VP, Advanced Systems and Technology, September 25, 1978.

16. *Furr, A. Keith; Lawerence, Alonzo W.; Tong, Steven S. C.; Gradolfo, Marian C.; Hofstader, Robert A.; Bache, Carl A.; Gutenmann, Walter; Lisk, Donald J. "Multielement and Chlorinated Hydrocarbon Analysis of Municipal Sewage Sludges of American Cities." *Environmental Science and Technology.* 10:7 (July 1976): 683–687.

17. General Electric Co. *Perspectives on PCB Substitutes For Power Capacitors.* Hudson Falls, NY: Capacitor Products Dept., (October 17, 1977). Submitted to Peter P. Principe, USEPA, OTS by Ruth K. Arisman, Materials Science Lab., March 9, 1978.

18. *General Electric Co. *Silicones in Transformers Presented to the Environmental Protection Agency.* Waterford, NY: Silicones Products Dept., (September 6, 1977).

19. *Hamelink, Jerry L.; Waybrant, Ronald C.; Ball, Robert C. "A Proposal: Exchange Equilibria Control the Degree Chlorinated Hydrocarbons are Biologically Magnified in Lentic Environments." *Transactions of the American Fisheries Society* 100:2 (April 1971): 207–214.

20. *Hague, Rizwanul; Schmedding, David W.; and Freed, Virgil M. "Aqueous Solubility Adsorption and Vapor Behavior by Polychlorinated Biphenyl Aroclor 1254." *Env. Sci. & Tech.* 8:2 (February 1974): 139–141.

21. *Harvey, George R., and Steinhauer, William C. "Atmospheric Transport of Polychlorobiphenyls to the North Atlantic." *Atmospheric Environment* 8 (1974): 777–782.

22. *Holden, A. V. "Source of Polychlorinated Biphenyl Contamination in the Marine Environment." *Nature* 228 (December 19, 1970): 1220–1221.

23. Hutzinger, O.; Safe, S.; and Zitko, V. "Polychlorinated Biphenyls." *Analabs Research Notes* 12:2 (July 1972): 1–15.

24. *Jansson, B.; Jensen, S.; Olsson, M.; Sundstrom, G.; and Vaz, R. "Identification by GC–MS of Phenolic Metabolites of PCB and p,p'-DDE Isolated from Baltic Guillemot and Seal." *Ambio* 4:2 (1975): 93–96.

Junge, C. E. *See* Suffet, I. H., gen. ed.

25. *Lunde, Gulbrand. "Long-Range Aerial Transmission of Organic Micropollutants." *Ambio* 5–6 (1976): 207–208.

26. *Mackay, Donald; Leinonen, Paul J. "Rate of Evaporation Low-Solubility Contaminants from Water Bodies to Atmosphere." *Environmental Science and Technology* 9 (December 1975): 1178–1180.

27. *Maugh, Thomas H. II. "DDT: An Unrecognized Source of Polychlorinated Biphenyls." *Science* 180 (May 1973): 578–579.

28. *Metcalf, Robert L.; Sanborn, James; Po Yung Lu; Nye, Donald. "Laboratory Model Ecosystem Studies of the Degradation and Fate of Radio labeled Tri-, Tetra-, and Pentachlorobiphenyl Compared with DDE." *Archives of Environmental Contamination and Toxicology* 3:2 (1975): 151–165.

29. *Monsanto Chemical Company. *Aroclor Plasticizers.* St. Louis, MO: Organic Chemicals Division, Technical Bulletin O/PL-306A (Undated).

---

*Denotes documents cited in the Environmental Protection Agency's *PCB Manufacturing, Processing, Distribution in Commerce and Use Ban Regulation: Proposed Rule—Support Document/Voluntary Draft Environmental Impact Statement.*

*Denotes documents cited in 43 F.R. 24802, June 7, 1978, "EPA, Polychlorinated Biphenyls (PCBs) Manufacturing, Processing Distribution in Commerce and Use Bans." Proposed Rule.

30. *Monsanto Chemical Company. *Monsanto To Shut Down PCB Unit, Exit Business by October 31, 1977.* St. Louis, MO: (October 5, 1977).

31. *Murphy, Thomas J. *Precipitation: A Significant Source of Phosphorus and PCBs to Lake Michigan.* Evanston, Ill.: 10th ACS Great Lakes Regional Meeting, (June 17, 1976).

32. *National Electric Manufacturers Association. *Report of Transformer Dielectric Fluid Study Working Group.* Washington, DC: (October 18, 1977).

33. *National Swedish Environmental Protection Board. *PCB Conference II.* Stockholm; Pub. 1973: 4E, (December 14, 1972).

34. *Nelson, N. "PCBs-Environmental Impact." *Environmental Research* 5 (1972): 273–287.

35. *New York State Department of Environmental Conservation. *Hudson River PCB Study Description and Detailed Work Plan.* Albany: Bureau of Water Research, (July 1977).

36. *Nisbet, Ian C. T. and Sarofim, Adel F. "Rates and Routes of Transport of PCBs in the Environment." *Environmental Health and Perspectives* (April 1972): 21–38.

37. *Oloffs, P. C.; Albright, L. J.; Szeto, S. Y.; and Law, J. "Factors Affecting the Behavior of Five Chlorinated Hydrocarbons in Two Natural Waters and Their Sediments." *Journal Fisheries Research Board of Canada* 30:11 (1973): 1619–1623.

Mr. Roberts.

38. + "PCBs spread by waste oil use?" *Chemical Week* (January 25, 1978): 15.

39. + Peakall, D. B. "PCBs and Their Environmental Effects." *CRC-Critical Reviews in Environmental Control* 5:4 (September 1975): 469–508.

40. *"Report of a New Chemical Hazard." *New Scientist* (December 15, 1966): 612.

41. *Risebrough, R. W.; Walker, W. II; Schmidt, T. T.; de Lappe, B. W.; Connors, C. W. "Transfer of Chlorinated Biphenyls to Antarctica." *Nature* 264 (December 23/30, 1976): 738–739.

42. *Sodergren, A. "Chlorinated Hydrocarbon Residues in Airborne Fallout." *Nature* 236: (April 21, 1972): 395–397.

43. Spagnoli, John J., and Skinner, Lawrence C. "PCBs in Fish From Selected Waters of New York State." *Pesticides Monitoring Journal* 11:2 (September 1977): 69–87.

44. *Suffet, I. H., gen. ed. *Fate of Pollutants in the Air and Water Environments.* New York: John Wiley & Sons, 1977, Vol. 8: "Basic Consideration about Trace Constituents in the Atmosphere as Related to the Fate of Global Pollutants." C. E. Junge, 7–25.

45. Tucker, E. S.; Litschgi, W. J.; Mees, W. M. "Migration of Polychlorinated Biphenyls in Soil Induced by Percolating Water." *Bulletin of Environmental Contamination & Toxicology* 13:1 (1975): 88–93.

46. + University of Wisconsin Sea Grant College Program. "ABCs of PCBs." Madison: *Public Information Report* WIS SG 76–125, (April 1976).

47. + University of Wisconsin Sea Grant College Program. "PCBs and the FDA, Parts I and II." Madison: *Earthwatch/Wisconsin,* (May 6 and May 13, 1977).

48. + USDHEW. *Final Report of the Subcommittee on the Health Effects of Polychlorinated Biphenyls and Polybrominated Biphenyls.* Washington, (July 1976).

49. ** USDHEW, Center for Disease Control. *Exposure to Polychlorinated Biphenyls in Bloomington, Indiana.* Atlanta: Public Health Service, EPI–77–35–2, (May 20, 1978). Submitted by Request of EPA during Reply Comment Period.

50. *USDHEW, NIOSH. *Criteria for a Recommended Standard . . . Occupational Exposure to Polychlorinated Biphenyls (PCBs).* Washington, (September 1977).

51. *USDHEW, NIOSH. *The Toxic Substances List–1973 Edition.* Rockville, MD: (June 1973), 95.

52. **USDHEW, PHS, NIH, NCI. *Bioassay of Aroclor 1254 for Possible Carcinogenicity.* Washington: National Cancer Institute, Tech. Report Series No. 38, (1978).

53. + USDOC, Maritime Administration. *Final Environmental Impact Statement.* Washington: Chemical Waste Incinerator Ship Project, Vol. 1 of 2 MA–EIS 7302–76041F, (July 2, 1976).

54. + USDOT, Transportation Systems Center. *Evaluation of Silicone Fluid for Replacement of PCB Coolants in Railway Industry.* Washington: Presented by Westinghouse Electric Corp., (July 1977).

55. + USEPA. *Proceedings In the Matter of Toxic Pollutant Effluent Standards. Docket No. 1 FWPCA(307).* Arlington, VA. (May 8, 1974).

56. + USEPA. *Proceedings In the Matter of Toxic Pollutant Effluent Standards. Docket No. 1 FWPCA(307).* Arlington, VA. (May 9, 1974).

57. *USEPA. *Proceedings In the Matter of Toxic Pollutant Effluent Standards. Docket No. 1 FWPCA(307).* Arlington, VA. (May 20, 1974).

58. *USEPA, Environmental Research Center. *Table of PCBs in Sewage Sludge.* Cincinnati, OH: OSWMP, Unpublished Report. (Undated).

59. *USEPA, Environmental Research Laboratory. *Polychlorobiphenyls in Precipitation in the Lake Michigan Basin-Draft.* Duluth, Minn., Office of Research & Development, (Undated).

60. *USEPA, OAWM. *Environmental Assessment of PCBs in the Atmosphere.* Research Triangle Park, NC, Mitre Corporation EPA 450/3–77–45, (November 1977).

61. *USEPA, OSWMP. *Municipal Sludge Agricultural Utilization Practices: An Environmental Assessment VI—Table 49. Chlorinated Hydrocarbon Concentrations in Stablized Sludge.* SCS Engineers, (Undated).

62. USEPA, OTS. *Assessment of the Environmental and Economic Impacts of the Ban on Imports of PCBs.* Versar, Inc. EPA 560/6–77–007. (July 1977).

63. *USEPA, OTS. *Destruction of PCBs in Sewage Sludge During Incineration.* Springfield, VA., Versar, Inc. PB–258–162, (1976).

64. USEPA, OTS. *Environmental Assessment of PCBs Near New Bedford, Mass. Municipal Landfill Final Draft.* Washington, DC, (May 1978).

65. *USEPA, OTS. *Environmental Levels of PCBs.* Washington, DC: unpublished Report by Doris J. Ruopp and Vincent J. DeCarlo, (Undated).

66. *USEPA, OTS. *A First Order Mass Balance Model for Sources, Distribution and Fate of PCBs in the Environment.* Washington, DC, Versar, Inc. EPA 560/6–77–006, (July 1977).

67. USEPA, OTS. *Identification and Analysis of Polychlorinated Biphenyls and Other Related Chemicals in Municipal Sewage Sludge Samples.* Research Triangle Institute. EPA 560/6–77–021. (August 1977).

68. *USEPA, Region I–OSWMP. *PCBs in Sewage Sludge.* Region I's Solid Waste Program's PCB Sampling Program. Pedco Environmental, (Updated).

69. *USEPA, Region VII, S/A Div. "Sludge Data Summary." (July 1, 1977).

70. *USEPA, Working Group on Pesticides. *Ground Disposal of Pesticides: The Problem and Criteria for Guidelines.* Washington, DC. PB 197–144, (March 1970).

71. *Veith, G. D., and Comstock, V. M. "Apparatus for Continuously Saturating Water with Hydrophobic Organic Chemicals." *J. Fish. Res. Bd. Canada* 32: 10 (1975): 1849–1851.

72. + Westinghouse Electric Corporation. *Proposal To: The Department of Transportation: Retrofilling of Railway Transformers.* Sharon, Pa.: H. A. Pearce, Project Manager, (December 21, 1977).

73. + Witco Chemical. *Coherex Dust Retardant Agent.* Bakersfield, CA: Golden Bear Division, (Undated).

74. *World Almanac & Book of Facts. "Meteorological Monthly Temperature and Precipitation." (1977): 794–795.

75. + World Health Organization. *Environmental Health Criteria 2. PCBs and Terphenyls.* Geneva. (1976): 43–45.

76. *World Health Organization. *Environmental Health Criteria for PCBs-Draft.* EHE/EHC/WP. 75.2 Rev. 2:26 (November 1975): 29.4.

77. *Wyndham, C.; Devenish, J.; and Safe S. "The In Vitro Metabolism, Macromolecular Binding and Bacteria Mutagenicity of 4—Chlorobiphenyl, A Model PCB Substrate." *Research Communications in Chemical Pathology and Pharmacology* 15:3 (November 1976): 563–570.

78. *Yoshimura, Hidetoshi, and Yamomoto, Hiroaki. "Metabolic Studies on PCBs. I. Metabolic Fate of 3,4,3′, 4′-tetrachlorobiphenyl in Rats." *Chem. Pharm. Bulletin* 21:5 (1973): 1168–1168.

Part 761 is revised to read as follows:

PART 761—POLYCHLORINATED BIPHENYLS (PCBs) MANUFACTURING, PROCESSING, DISTRIBUTION IN COMMERCE, AND USE PROHIBITIONS

Subpart A—General

Sec.
761.1 Applicability.
761.2 Definitions.

***Denotes documents cited in the Environmental Protection Agency's Support Document/Voluntary Environmental Impact Statement for Polychlorinated Biphenyls (PCB) Manufacturing Processing, Distribution in Commerce and Use Ban Regulation: March 1979*

Reproduced from best available copy.

Subpart B—Disposal of PCBs and PCB Items

761.10 Disposal requirements.

Subpart C—Marking of PCBs and PCB Items

761.20 Marking requirement.

Subpart D—Manufacturing, Processing, Distribution in Commerce, and Use of PCBs and PCB Items

761.30 Prohibitions.
761.31 Authorizations.
761.32 [Reserved]

Subpart E—List of Annexes

Annex No. I

761.40 Incineration.

Annex No. II

761.41 Chemical waste landfills.

Annex No. III

761.42 Storage for disposal.

Annex No. IV

761.43 Decontamination.

Annex No. V

761.44 Marking formats.

Annex No. VI

761.45 Records and Monitoring.

Authority: Section 6, 8, and 12, Toxic Substances Control Act, 15 U.S.C. 2605, 2607, and 2611.

Subpart A—General

§ 761.1 Applicability.

(a) This part establishes prohibitions of, and requirements for, the manufacture, processing, distribution in commerce, use, disposal, storage, and marking of PCBs and PCB Items.

(b) This part applies to all persons who manufacture, process, distribute in commerce, use, or dispose of PCBs or PCB Items. Unless it is otherwise specifically provided, the terms PCB and PCBs are used in this rule to refer to any chemical substances and combinations of substances that contain 50 ppm (on a dry weight basis) or greater of PCBs, as defined in § 761.2(s), including any byproduct, intermediate, or impurity manufactured at any point in a process. Any chemical substances and combinations of substances that contain less than 50 ppm PCBs because of any dilution, shall be included as PCB and PCBs unless otherwise specifically provided. Substances that are regulated by this rule include, but are not limited to, dielectric fluids, contaminated solvents, oils, waste oils, heat transfer fluids, hydraulic fluids, paints, sludges, slurries, dredge spoils, soils, materials contaminated as a result of spills, and other chemical substances or combination of substances, including impurities and byproducts.

(c) Definitions of the terms used in these regulations are in Subpart A. The basic requirements applicable to disposal and marking of PCBs and PCB Items are set forth in Subpart B—Disposal of PCBs and PCB Items and in Subpart C—Marking of PCBs and PCB Items. Prohibitions applicable to PCB activities are set forth in Subpart D—Manufacture, Processing, Distribution in Commerce, and Use of PCBs and PCB Items. Subpart D also includes authorizations from the prohibitions. The Annexes in Subpart E set forth the specific requirements for disposal and marking of PCBs and PCB Items.

(d) Section 15 of the Toxic Substances Control Act (TSCA) states that failure to comply with these regulations is unlawful. Section 16 imposes liability for civil penalties upon any person who violates these regulations, and the Administrator can establish appropriate remedies for any violations subject to any limitations included in § 16 of TSCA. Section 16 also subjects a person to criminal prosecution for a violation which is knowing or willful. In addition, § 17 authorizes Federal district courts to enjoin activities prohibited by these regulations, compel the taking of actions required by these regulations, and issue orders to seize PCBs and PCB Items manufactured, processed or distributed in violation of these regulations.

(e) These regulations do not preempt other more stringent Federal statutes and regulations.

§ 761.2 Definitions.

For the purpose of this part:

(a) "Administrator" means the Administrator of the Environmental Protection Agency, or any employee of the Agency to whom the Administrator may either herein or by order delegate his authority to carry out his functions, or any person who shall by operation of law be authorized to carry out such functions.

(b) "Agency" means the United States Environmental Protection Agency.

(c) "Byproduct" means a chemical substance produced without separate commercial intent during the manufacturing or processing of another chemical substance(s) or mixture(s).

(d) "Capacitor" means a device for accumulating and holding a charge of electricity and consisting of conducting surfaces separated by a dielectric. Types of capacitors are as follows:

(1) "Small Capacitor" means a capacitor which contains less than 1.36 kg (3 lbs.) of dielectric fluid.

(2) "Large High Voltage Capacitor" means a capacitor which contains 1.36 kg (3 lbs.) or more of dielectic fluid and which operates at 2000 volts a.c. or above.

(3) "Large Low Voltage Capacitor" means a capacitor which contains 1.36 kg (3 lbs.) or more of dielectric fluid and which operates below 2000 volts a.c.

(e)(1) "Chemical Substance", except as provided in subparagraph (2) of this paragraph, means any organic or inorganic substance of a particular molecular identity, including:

(i) Any combination of such substances occurring in whole or part as a result of a chemical reaction or occurring in nature, and

(ii) Any element or uncombined radical.

(2) Such term does not include:

(i) Any mixture,

(ii) Any pesticide (as defined in the Federal Insecticide, Fungicide, and Rodenticide Act) when manufactured, processed, or distributed in commerce for use as a pesticide,

(iii) Tobacco or any tobacco product,

(iv) Any source material, special nuclear material, or by product material (as such terms are defined in the Atomic Energy Act of 1954 and regulations issued under such Act),

(v) Any arcticle the sale of which is subject to the tax imposed by section 4181 of the Internal Revenue Code of 1954 (determined without regard to any exemptions from such tax provided by section 4182 or section 4221 or any provisions of such Code), and

(vi) Any food, food additive, drug, cosmetic, or device (as such terms are defined in section 201 of the Federal Food, Drug, and Cosmetic Act) when manufactured, processed, or distributed in commerce for use as a food, food additive, drug, cosmetic, or device.

(f) "Chemical Waste Landfill" means a landfill at which protection against risk of injury to health or the environment from migration of PCBs to land, water, or the atmosphere is provided from PCBs and PCB Items deposited therein by locating, engineering, and operating the landfill as specified in § 761.41.

(g) "Commerce" means trade, traffic, transportation, or other commerce:

(1) Between a place in a State and any place outside of such State, or

(2) Which affects trade, traffic, transportation, or commerce described in subparagraph (1) of this paragraph.

(h) "Disposal" means to intentionally or accidentally discard, throw away, or otherwise complete or terminate the useful life of PCBs and PCB Items. Disposal includes actions related to containing, transporting, destroying, degrading, decontaminating, or confining PCBs and PCB Items.

(i) "Distribute in Commerce" and "Distribution in Commerce" when used to describe an action taken with respect to a chemical substance, mixture, or article containing a substance or mixture means to sell, or the sale of, the substance, mixture, or article in commerce; to introduce or deliver for introduction into commerce, or the introduction or delivery for introduction into commerce of the substance, mixture, or article; or to hold or the holding of, the substance, mixture, or article after its introduction into commerce.

(j) "Fluorescent Light Ballast" means a device that electrically controls fluorescent light fixtures and that includes a capacitor containing 0.1 kg or less of dielectic.

(k) "Impurity" means a chemical substance which is unintentionally present with another chemical substance.

(l) "Incinerator" means an engineered device using controlled flame combustion to thermally degrade PCBs and PCB Items. Examples of devices used for incineration include rotary kilns, liquid injection incinerators, cement kilns, and high temperature boilers.

(m) "Leak" or "leaking" means any instance in which a PCB Article, PCB Container, or PCB Equipment has any PCBs on any portion of its external surface.

(n) "Manufacture" means to produce, manufacture, or import into the customs territory of the United States.

(o) "Mark" means the descriptive name, instructions, cautions, or other information applied to PCBs and PCB Items, or other objects subject to these regulations.

(p) "Marked" means the marking of PCB Items and PCB storage areas and transport vehicles by means of applying a legible mark by painting, fixation of an adhesive label, or by any other method that meets the requirements of these regulations.

(q) "Mixture" means any combination of two or more chemical substances if the combination does not occur in nature and is not, in whole or in part, the result of a chemical reaction; except that such term does include any combination which occurs, in whole or in part, as a result of a chemical reaction if none of the chemical substances comprising the combination is a new chemical substance and if the combination could have been manufactured for commercial purposes without a chemical reaction at the time the chemical substances comprising the combination were combined.

(r) "Municipal Solid Wastes" means garbage, refuse, sludges, wastes, and other discarded materials resulting from residential and non-industrial operations and activities, such as household activities, office functions, and commercial housekeeping wastes.

(s) "PCB" and "PCBs" means any chemical substance that is limited to the biphenyl molecule that has been chlorinated to varying degrees or any combination of substances which contains such substance. (See § 761.1(b) Applicability for applicable concentrations of PCBs). PCB and PCBs as contained in PCB Items are defined in § 761.2(x).

(t) "PCB Article" means any manufactured article, other than a PCB Container that contains PCBs and whose surface(s) has been in direct contact with PCBs. "PCB Article" includes capacitors, transformers, electric motors, pumps, pipes and any other manufactured item (1) which is formed to a specific shape or design during manufacture, (2) which has end use function(s) dependent in whole or in part upon its shape or design during end use, and (3) which has either no change of chemical composition during its end use or only those changes of composition which have no commercial purpose separate from that of the PCB Article.

(u) "PCB Article Container" means any package, can, bottle, bag, barrel, drum, tank or other device used to contain PCB Articles or PCB Equipment, and whose surface(s) has not been in direct contact with PCBs.

(v) "PCB Container" means any package, can, bottle, bag, barrel, drum, tank, or other device that contains PCBs or PCB Articles and whose surface(s) has been in direct contact with PCBs.

(w) "PCB Equipment" means any manufactured item, other than a PCB Container or a PCB Article Container, which contains a PCB Article or other PCB Equipment, and includes microwave ovens, electronic equipment, and fluorescent light ballasts and fixtures.

(x) "PCB Item" is defined as any PCB Article, PCB Article Container, PCB Container, or PCB Equipment, that deliberately or unintentionally contains or has as a part of it any PCB or PCBs at a concentration of 50 ppm or greater.

(y) "PCB Transformer" means any transformer that contains 500 ppm PCB or greater.

(z) "PCB-Contaminated Transformer" means any transformer that contains 50 ppm or greater of PCB but less than 500 ppm PCB (See § 761.31(a)(5) for provisions permitting reclassifying PCB Transformers to PCB-Contaminated Transformers).

(aa) "Person" means any natural or judicial person including any individual, corporation, partnership, or association; any State or political subdivision thereof; any interstate body; and any department, agency, or instrumentality of the Federal Government.

(bb) "Process" means the preparation of a chemical substance or mixture, after its manufacture, for distribution in commerce:

(1) In the same form or physical state as, or in a different form or physical state from, that in which it was received by the person so preparing such substance or mixture, or

(2) As part of an article containing the chemical substance or mixture.

(cc) "Sale for Purposes Other than Resale" means sale of PCBs for purposes of disposal and for purposes of use, except where use involves sale for distribution in commerce. PCB Equipment which is first leased for purposes of use any time before July 1, 1979, will be considered sold for purposes other than resale.

(dd) "Significant Exposure" means any exposure of human beings or the environment to PCBs as measured or detected by any scientifically acceptable analytical method.

(ee) "Small Quantities for Research and Development" means any quantity of PCBs (1) that is originally packaged in one or more hermetically sealed containers of a volume of no more than five (5.0) milliliters, and (2) that is used only for purposes of scientific experimentation or analysis, or chemical research on, or analysis of, PCBs, but not for research or analysis for the development of a PCB product.

(ff) "Storage for Disposal" means temporary storage of PCBs that have been designated for disposal.

(gg) "Transport Vehicle" means a motor vehicle or rail car used for the transportation of cargo by any mode. Each cargo-carrying body (e.g., trailer, railroad freight car) is a separate transport vehicle.

(hh) "Totally Enclosed Manner" means any manner that will ensure that any exposure of human beings or the environment to any concentration of PCBs will be insignificant; that is, not measurable or detectable by any scientifically acceptable analytical method.

(ii) "Waste Oil" means used products primarily derived from petroleum, which include, but are not limited to, fuel oils, motor oils, gear oils, cutting oils, transmission fluids, hydraulic fluids, and dielectric fluids.

Subpart B—Disposal of PCBs and PCB Items

Note.—This Subpart does not require removal of PCBs and PCB Items from service and disposal earlier than would normally be the case. However, when PCBs and PCB Items are removed from service and disposed of, disposal must be undertaken in accordance with these regulations. PCBs (including soils and debris) and PCB Items which have been placed in a disposal site are considered to be "in service" for purposes of the applicability of this Subpart. This Subpart does not require PCBs and PCB Items landfilled prior to February 17, 1978 to be removed for disposal. However, if such PCBs or PCB Items are removed from the disposal site, they must be disposed of in accordance with this Subpart. Other Subparts are directed to the manufacture, processing, distribution in commerce, and use of PCBs and may result in some cases in disposal at an earlier date than would otherwise occur.

§ 761.10 Disposal requirements.

(a) *PCBs.* (1) Except as provided in subparagraphs (2), (3), (4), and (5) of this paragraph, PCBs must be disposed of in an incinerator which complies with Annex I.

(2) Mineral oil dielectric fluid from PCB-Contaminated Transformers containing a PCB concentration of 50 ppm or greater, but less than 500 ppm, must be disposed of in one of the following:

(i) In an incinerator that complies with Annex I § 761.40;

(ii) In a chemical waste landfill that complies with Annex II § 761.41 if information is provided to the owner or operator of the chemical waste landfill that shows that the mineral oil dielectric fluid does not exceed 500 ppm PCB and is not an ignitable waste as described in § 761.41 (b) (8) (iii) of Annex II;

(iii) In a high efficiency boiler provided that:

(A) The boiler complies with the following criteria:

(*1*) The boiler is rated at a minimum of 50 million BTU hours;

(*2*) If the boiler uses natural gas or oil as the primary fuel, the carbon monoxide concentration in the stack is 50 ppm or less and the excess oxygen is at least three (3) percent when PCBs are being burned;

(*3*) If the boiler uses coal as the primary fuel, the carbon monoxide concentration in the stack is 100 ppm or less and the excess oxygen is at least three (3) percent when PCBs are being burned;

(*4*) The mineral oil dielectric fluid does not comprise more than ten (10) percent (on a volume basis) of the total fuel feed rate;

(*5*) The mineral oil dielectric fluid is not fed into the boiler unless the boiler is operating at its normal operating temperature (this prohibits feeding these fluids during either start up or shut down operations);

(*6*) The owner or operator of the boiler:

(*i*) Continuously monitors and records the carbon monoxide concentration and excess oxygen percentage in the stack gas while burning mineral oil dielectric fluid; or

(*ii*) If the boiler will burn less than 30,000 gallons of mineral oil dielectric fluid per year, measures and records the carbon monoxide concentration and excess oxygen percentage in the stack gas at regular intervals of no longer than 60 minutes while burning mineral oil dielectric fluid.

(*7*) The primary fuel feed rates, mineral oil dielectric fluid feed rates, and total quantities of both primary fuel and mineral oil dielectric fluid fed to the boiler are measured and recorded at regular intervals of no longer than 15 minutes while burning mineral oil dielectric fluid.

(*8*) The carbon monoxide concentration and the excess oxygen percentage are checked at least once every hour that mineral oil dielectric fluid is burned. If either measurement falls below the levels specified in this rule, the flow of mineral oil dielectric fluid to the boiler shall be stopped immediately."

(B) Thirty days before any person burns mineral oil dielectric fluid in the boiler, the person gives written notice to the EPA Regional Administrator for the EPA Region in which the boiler is located and that the notice contains the following information:

(*1*) The name and address of the owner or operator of the boiler and the address of the boiler;

(*2*) The boiler rating in units of BTU/hour;

(*3*) The carbon monoxide concentration and the excess oxygen percentage in the stack of the boiler when it is operated in a manner similar to the manner in which it will be operated when mineral oil dielectric fluid is burned; and

(*4*) The type of equipment, apparatus, and procedures to be used to control the feed of mineral oil dielectric fluid to the boiler and to monitor and record the carbon monoxide concentration and excess oxygen percentage in the stack.

(C) When burning mineral oil dielectric fluid, the boiler must operate at a level of output no less than the output at which the measurements required under subparagraph (B)(*3*) were taken.

(D) Any person burning mineral oil dielectric fluid in a boiler obtains the following information and retains the information for five years at the boiler location:

(*1*) The data required to be collected under subparagraphs (A)(*6*) and (A)(*7*) of this paragraph; and

(*2*) The quantity of mineral oil dielectric fluid burned in the boiler each month;

(iv) In a facility that is approved in accordance with § 761.10(e). For the purpose of burning mineral oil dielectric fluid, an applicant under § 761.10(e) must show that his combustion process destroys PCBs as efficiently as does a high efficiency boiler, as defined in subparagraph (iii), or an Annex I approved incinerator.

(3) Liquids, other than mineral oil dielectric fluid, containing a PCB concentration of 50 ppm or greater, but less than 500 ppm, shall be disposed of:

(i) In an incinerator which complies with Annex I;

(ii) In a chemical waste landfill which complies with Annex II if information is provided to the owner or operator of the chemical waste landfill that shows that the waste does not exceed 500 ppm PCB and is not an ignitable waste as described in § 761.41(b)(8)(iii) of Annex II.

(iii) In a high efficiency boiler provided that:

(A) The boiler complies with the following criteria:

(*1*) The boiler is rated at a minimum of 50 million BTU/hour;

(*2*) If the boiler uses natural gas or oil as the primary fuel, the carbon monoxide concentration in the stack is 50 ppm or less and the excess oxygen is at least three (3) percent when PCBs are being burned;

(*3*) If the boiler uses coal as the primary fuel, the carbon monoxide concentration in the stack is 100 ppm or less and the excess oxygen is at least three (3) percent when PCBs are being burned;

(*4*) The waste does not comprise more than ten (10) percent (on a volume basis) of the total fuel feed rate;

(*5*) The waste is not fed into the boiler unless the boiler is operating at its normal operating temperature (this prohibits feeding these fluids during either start up or shut down operations);

(*6*) The owner or operator of the boiler must:

(*i*) Continuously monitor and record the carbon monoxide concentration and excess oxygen percentage in the stack gas while burning waste fluid; or

(*ii*) If the boiler will burn less than 30,000 gallons of waste fluid per year, measure and record the carbon monoxide concentration and excess oxygen percentage in the stack gas at regular intervals of no longer than 60 minutes while burning waste fluid;

(*7*) The primary fuel feed rate, waste fluid feed rate, and total quantities of both primary fuel and waste fluid fed to the boiler must be measured and recorded at regular intervals of no longer than 15 minutes while burning waste fluid; and

(*8*) The carbon monoxide concentration and the excess oxygen percentage must be checked at least once every hour that the waste is burned. If either measurement falls below the levels specified in this rule, the flow of waste to the boiler shall be stopped immediately.

(B) Prior to any person burning these liquids in the boiler, approval must be obtained from the EPA Regional Administrator for the EPA Region in which the boiler is located and any persons seeking such approval must submit to the EPA Regional Administrator a request containing at least the following information:

(*1*) The name and address of the owner or operator of the boiler and the address of the boiler;

(*2*) The boiler rating in units of BTU/hour;

(*3*) The carbon monoxide concentration and the excess oxygen percentage in the stack of the boiler when it is operated in a manner similar to the manner in which it will be operated when low concentration PCB liquid is burned;

(*4*) The type of equipment, apparatus, and procedures to be used to control the feed of mineral oil dielectric fluid to the boiler and to monitor and record the carbon monoxide concentration and excess oxygen percentage in the stack;

(*5*) The type of waste to be burned (e.g., hydraulic fluid, contaminated fuel oil, heat transfer fluid, etc.);

(*6*) The concentration of PCBs and of any other chlorinated hydrocarbon in the waste and the results of analyses using the American Society of Testing and Materials (ASTM) methods as referenced below: carbon and hydrogen content using ASTM D–3178, nitrogen content using ASTM E–258, sulfur content using ASTM D–2784, D–1266, or D–129, chlorine content using ASTM D–808, water and sediment content using either ASTM D–2709 or D–1796, ash content using D–482, calorific value using ASTM D–240, carbon residue using either ASTM D–2158 or D–524, and flash point using ASTM D–93;

(*7*) The quantity of wastes estimated to be burned in a thirty (30) day period;

(*8*) An explanation of the procedures to be followed to insure that burning the waste will not adversely affect the operation of the boiler such that combustion efficiency will decrease.

(C) On the basis of the information in (B) above and any other available information, the Regional Administrator may, at his discretion, find that the alternate disposal method will not present an unreasonable risk of injury to health or the environment and approve the use of the boiler;

(D) When burning PCB wastes, the boiler must operate at a level of output no less than the output at which the measurements required under subparagraph (B)(*3*) were taken; and

(E) Any person burning liquids in boilers approved as provided in (C) above, must obtain the following information and retain the information for five years at the boiler location:

(*1*) The data required to be collected in subparagraphs (A)(*6*) and (A)(*7*) of this paragraph;

(*2*) The quantity of low concentration PCB liquid burned in the boiler each month.

(*3*) The analysis of the waste required by subparagraph (B)(*6*) of this paragraph taken once a month for each month during which low concentration PCB liquid is burned in the boiler.

(iv) In a facility that is approved in accordance with § 761.10(e). For the purpose of burning liquids, other than mineral oil dielectric fluid, containing 50 ppm or greater PCB, but less than 500 ppm PCB, an applicant under § 761.10(e) must show that his combustion process destroys PCBs as efficiently as does a high efficiency boiler, as defined in § 761.10(a)(2)(iii), or an Annex I incinerator.

(4) Any non-liquid PCBs in the form of contaminated soil, rags, or other debris shall be disposed of:

(i) In an incinerator which complies with Annex I; or

(ii) In a chemical waste landfill which complies with Annex II.

Note: Except as provided in § 761.41(b)(8)(ii), liquid PCBs shall not be processed into non-liquid forms to circumvent the high temperature incineration requirements of § 761.10(a).

(5) All dredged materials and municipal sewage treatment sludges that contain PCBs shall be disposed of:

(i) In an incinerator which complies with Annex I;

(ii) In a chemical waste landfill which complies with Annex II; or

(iii) Upon application, using a disposal method to be approved by the Agency's Regional Administrator in the EPA Region in which the PCBs are located. Applications for disposal in a manner other than prescribed in (i) or (ii) above must be made in writing to the Regional Administrator. The application must contain information that, based on technical, environmental, and economic considerations, indicates that disposal in an incinerator or chemical waste landfill is not reasonable and appropriate, and that the alternate disposal method will provide adequate protection to health and the environment. The Regional Administrator may request other information that he or she believes to be necessary for evaluation of the alternate disposal method. Any approval by the Regional Administrator shall be in writing and may contain any appropriate limitations on the approved alternate method for disposal. In addition to these regulations, the Regional Administrator shall consider other applicable Agency guidelines, criteria, and regulations to ensure that the discharges of dredged material and sludges that contain PCBs and other contaminants are adequately controlled to protect the environment. The person to whom such approval is issued must comply with all limitations contained in the approval.

(6) When storage is desired prior to disposal, PCBs shall be stored in a facility which complies with Annex III.

(b) *PCB Articles.* (1) Transformers.

(i) PCB Transformers shall be disposed of in accordance with either of the following:

(A) In an incinerator that complies with Annex I; or

(B) In a chemical waste landfill which complies with Annex II; provided that the transformer is first drained of all free flowing liquid, filled with solvent, allowed to stand for at least 18 hours, and then drained thoroughly. PCB liquids that are removed shall be disposed of in accordance with paragraph (a) of this section. Solvents may include kerosene, xylene, toluene and other solvents in which PCBs are readily soluble. Precautionary measures should be taken, however, that the solvent flushing procedure is conducted in accordance with applicable safety and health standards as required by Federal or State regulations.

(ii) PCB-Contaminated Transformers shall be disposed of by draining all free flowing liquid from the transformer and disposing of the liquid in accordance with paragraphs (a)(2) above. The disposal of the drained transformer is not regulated by this rule.

(2) PCB Capacitors. (i) The disposal of any capacitor normally used in alternating current circuits shall comply with all requirements of this subpart unless it is known from label or nameplate information, manufacturer's literature, or chemical analysis that the capacitor does not contain PCBs.

(ii) Any person may dispose of PCB Small Capacitors as municipal solid waste, unless that person is subject to the requirements of subparagraph (iv).

(iii) Any PCB Large High or Low Voltage Capacitor owned by any person shall be disposed of in accordance with either of the following:

(A) Disposal in an incinerator that complies with Annex I; or

(B) Until January 1, 1980, disposal in a chemical waste landfill that complies with Annex II.

(iv) Any PCB Small Capacitor owned by any person who manufactures or at any time manufactured PCB Capacitors or PCB Equipment and acquired the PCB Capacitors in the course of such manufacturing shall be disposed of in accordance with either of the following:

(A) Disposal in an incinerator which complies with Annex I; or

(B) Until January 1, 1980, disposal in a chemical waste landfill which complies with Annex II.

(3) PCB Hydraulic Machines. PCB hydraulic machines such as die casting machines may be disposed of as municipal solid waste or salvage provided that the machines are drained of all free-flowing liquid and the liquid is disposed of in accordance with the provisions of § 761.10(a). If the PCB liquid contains 1000 ppm PCB or greater, then the hydraulic machine must be flushed prior to disposal with a solvent containing less than 50 ppm PCB (see transformer solvents at § 761.10(b)(1)(i)(B)) and the solvent disposed of in accordance with § 761.10(a).

(4) Other PCB Articles must be disposed of:

(i) In an incinerator that complies with Annex I; or

(ii) In a chemical waste landfill that complies with Annex II, provided that all free-flowing liquid PCBs have been thoroughly drained from any articles before the articles are placed in the chemical waste landfill and that the drained liquids are disposed of in an incinerator that complies with Annex I.

(5) Storage of PCB Articles—Except for a PCB Article described in subparagraph (b)(2)(ii) and hydraulic machines that comply with the municipal solid waste disposal provisions described in subparagraph (b)(3), any PCB Article shall be stored in accordance with Annex III prior to disposal.

(c) *PCB Containers.* (1) Unless decontaminated in compliance with Annex IV or as provided in (2) below, a PCB Container shall be disposed of:

(i) In an incinerator which complies with Annex I, or

(ii) In a chemical waste landfill that complies with Annex II; provided that if there are PCBs in a liquid state, the PCB Container shall first be drained and the PCB liquid disposed of in accordance with paragraph (a) of this section.

(2) Any PCB Container used to contain only PCBs at a concentration less than 500 ppm shall be disposed of as municipal solid wastes; provided that if the PCBs are in a liquid state, the PCB Container shall first be drained and the PCB liquid shall be disposed of in accordance with paragraph (a) of this section.

(3) Prior to disposal, a PCB container shall be stored in a facility which complies with Annex III.

(d) *Spills.* (1) Spills and other uncontrolled discharges of PCBs constitute the disposal of PCBs.

(2) PCBs resulting from spill clean-up and removal operations shall be stored and disposed of in accordance with paragraph (a) of this section. In order to determine if a spill of PCBs has resulted in a contamination level that is 50 ppm of PCBs or greater in soil, gravel, sludge, fill, rubble, or other land based substances, the person who spills PCBs should consult with the appropriate EPA Regional Administrator to obtain information on sampling methods and analytical procedures for determining the PCB contamination level associated with the spill.

(3) This paragraph does not exempt any person from any actions or liability under other statutory authorities, including section 311 of the Clean Water Act and the Resource Conservation and Recovery Act.

(e) Any person who is required to incinerate any PCBs and PCB Items under this subpart and who can demonstrate that an alternative method of destroying PCBs and PCB Items exists and that this alternative method can achieve a level of performance equivalent to Annex I incinerators or high efficiency boilers as provided in § 761.10(a)(2)(iv) and § 761.10(a)(3)(iv), may submit a written request to the Regional Administrator for an exemption from the incineration requirements of Annex I. The applicant must show that his method of destroying PCBs will not present an unreasonable risk of injury to health or the environment. On the basis of such information and any available information, the Regional Administrator may, in his discretion, approve the use of the alternate if he finds that the alternate disposal method provides PCB destruction equivalent to disposal in an Annex I incinerator and will not present an unreasonable risk of injury to health or the environment. Any approval must be stated in writing and may contain such conditions and provisions as the Regional Administrator deems appropriate. The person to whom such waiver is issued must comply with all limitations contained in such determination.

(f)(1) Each operator of a chemical waste landfill, incinerator, or alternative to incineration approved under paragraph (e) shall give the following written notices to the state and local governments within whose jurisdiction the disposal facility is located:

(i) Notice at least thirty (30) days before a facility is first used for disposal of PCBs required by these regulations, and

(ii) At the request of any state or local government, annual notice of the quantities and general description of PCBs disposed of during the year. This annual notice shall be given no more than thirty (30) days after the end of the year covered.

(2) Any person who disposes of PCBs under a §761.10(a)(5)(iii) incineration or chemical waste landfilling waiver shall give written notice at least thirty (30) days prior to conducting the disposal activities to the state and local governments within whose jurisdiction the disposal is to take place.

(g) *Testing Procedures.*

(1) Owners or users of mineral oil dielectric fluid transformers may use the following procedures to determine the concentration of PCBs in the dielectric fluid:

(i) Dielectric fluid removed from mineral oil dielectric fluid transformers may be collected in a common container, provided that no other chemical substances or mixtures are added to the container.

(ii) For purposes of complying with the marking and disposal requirements, representative samples may be taken from either the common containers or the individual transformers to determine the PCB concentration, *except that* if any PCBs at a concentration of 500 ppm or greater have been added to the container then the total container contents must be considered as having a PCB concentration of 500 ppm or greater for purposes of complying with the disposal requirements of this subpart. For purposes of this subparagraph, representative samples of mineral oil dielectric fluid are either samples taken in accordance with American Society of Testing and Materials method D-923 or samples taken from a container that has been thoroughly mixed in a manner such that any PCBs in the container are uniformly distributed throughout the liquid in the container.

(2) Owners or users of waste oil may use the following procedures to determine the PCB concentration of waste oil:

(i) Waste oil from more than one source may be collected in a common container, provided that no other chemical substances or mixtures, such as non-waste oils, are added to the container.

(ii) For purposes of complying with the marking and disposal requirements, representative samples may be taken from either the common container or individual containers to determine the PCB concentration *except that* if any PCBs at a concentration of 500 pm or greater have been added to the container then the total container contents must be considered as having a PCB concentration of 500 ppm or greater for purposes of complying with the disposal requirements of this subpart. For purposes of this subparagraph, representative samples of waste oil are either samples taken in accordance with American Society of Testing and Materials D-923 method or samples taken from a container that has been thoroughly mixed in a manner such that any PCBs in the container are uniformly distributed throughout the liquid in the container.

(h) Requirements for export and import of PCBs for purposes of disposal and PCB Items for purposes of disposal are found in § 761.30.

Subpart C—Marking of PCBs and PCB Items

§ 761.20 Marking requirements.

(a) Each of the following items in existence on or after July 1, 1978 shall be marked as illustrated in Figure 1 in Annex V—§ 761.44(a): The mark illustrated in Figure 1 is referred to as M_L throughout this subpart.

(1) PCB Containers;

(2) PCB Transformers at the time of manufacture, at the time of distribution in commerce if not already marked, and at the time of removal from use if not already marked. [Marking of PCB—Contaminated Transformers is not required];

(3) PCB Large High Voltage Capacitors at the time of manufacture, at the time of distribution in commerce if not already marked, and at the time of removal from use if not already marked;

(4) Equipment containing a PCB Transformer or a PCB Large High Voltage Capacitor at the time of manufacture, at the time of distribution in commerce if not already marked, and at the time of removal of the equipment from use if not already marked;

(5) PCB Large Low Voltage Capacitors at the time of removal from use;

(6) Electric motors using PCB coolants (See also § 761.20(e)).

(7) Hydraulic systems using PCB hydraulic fluid (See also § 761.20(e));

(8) Heat transfer systems (other than PCB Transformers) using PCBs (See also § 761.20(e));

(9) PCB Article Containers containing articles or equipment that must be marked under provisions (1) through (8) above;

(10) Each storage area used to store PCBs and PCB Items for disposal.

(b) As of October 1, 1978, each transport vehicle shall be marked on each end and side with M_L as described in Annex V—§ 761.44(a) if it is loaded with PCB Containers that contain more than 45 kg (99.4 lbs.) of PCBs in the liquid phase or with one or more PCB Transformers (See also § 761.20(e)).

(c) As of January 1, 1979, the following PCB Articles shall be marked with mark M_L as described in Annex V—§ 761.44(a):

(1) All PCB Transformers not marked under paragraph (a) of this section (Marking of PCB-Contaminated Transformers is not required);

(2) All PCB Large High Voltage Capacitors not marked under paragraph (a) of this section

(i) Will be marked individually with mark M_L, or

(ii) If one or more PCB Large High Voltage Capacitors are installed in a protected location such as on a power pole, or structure, or behind a fence; the pole, structure, or fence shall be marked with mark M_L, and a record or procedure identifying the PCB Capacitors shall be maintained by the owner or operator at the protected location.

(d) As of January 1, 1979, all PCB Equipment containing a PCB Small Capacitor shall be marked at the time of manufacture with the statement, "This equipment contains PCB Capacitor(s)". The mark shall be of the same size as the mark M_L.

(e) As of October 1, 1979, applicable PCB Items in paragraphs (a)(1), (6), (7), and (8) containing PCBs in concentrations of 50 to 500 ppm and applicable transport vehicles in paragraph (b) loaded with PCB Containers that contain more than 45 kg (99.4 lbs.) of liquid PCBs in concentrations of 50 ppm to 500 ppm shall be marked with mark M_L as described in Annex V—§ 761.44(a).

(f) Where mark M_L is specified but the PCB Article or PCB Equipment is too small to accomodate the smallest permissible size of mark M_L, mark M_S as described in Annex V—§ 761.44(b), may be used instead of mark M_L.

(g) Each large low voltage capacitor, each small capacitor normally used in alternating current circuits, and each fluorescent light ballast manufactured ("manufactured", for purposes of this sentence, means built) between July 1, 1978 and July 1, 1998 that do not contain PCBs shall be marked by the manufacturer at the time of manufacture with the statement, "No PCBs". The mark shall be of similar durability and readability as other marking that indicate electrical information, part numbers, or the manufacturer's name. For purposes of this subparagraph marking requirement only is applicable to items built domestically or abroad after June 30, 1978.

(h) All marks required by this subpart must be placed in a position on the exterior of the PCB Items or transport vehicles so that the marks can be easily read by any persons inspecting or servicing the marked PCB Items or transport vehicles.

(i) Any chemical substance or mixture that is manufactured after the effective date of this rule and that contains less than 500 ppm PCB (0.05% on a dry weight basis), including PCB that is a byproduct or impurity, must be marked in accordance with any requirements contained in the exemption granted by EPA to permit such manufacture and is not subject to any other requirement in this Subpart unless so specified in the exemption. This paragraph applies only to containers of chemical substances or mixtures. PCB articles and equipment into which the chemical substances or mixtures are processed, are subject to the marking requirements contained elsewhere in this Subpart.

Subpart D—Manufacturing, Processing, Distribution in Commerce, and Use of PCBs and PCB Items

§ 761.30 Prohibitions.

Except as authorized in § 761.31, the activities listed in paragraphs (a) and (d) of this section are prohibited pursuant to section 6(e)(2) of TSCA. The requirements set forth in paragraphs (b) and (c) of this section concerning export and import of PCBs for purposes of disposal and PCB Items for purposes of disposal are established pursuant to section 6(e)(1) of TSCA. Subject to any exemptions granted pursuant to section 6(e)(3)(B) of TSCA, the activities listed in paragraphs (b) and (c) of this section are prohibited pursuant to section 6(e)(3)(A) of TSCA. In addition, the Administrator hereby finds, under the authority of section 12(a)(2) of TSCA, that the manufacture, processing, and distribution in commerce of PCBs and PCB Items for export from the United States presents an unreasonable risk of injury to health within the United States. This finding is based upon the well-documented human health and environmental hazard of PCB exposure; the high probability of human and environmental exposure to PCBs and PCB Items from manufacturing, processing, or distribution activities; the potential hazard of PCB exposure posed by the transportation of PCBs or PCB Items within the United States; and the evidence that contamination of the environment by PCBs is spread far beyond the areas where they are used. In addition, the Administrator hereby finds that any exposure of human beings or the environment to PCBs as measured or detected by any scientifically acceptable analytical method is a significant exposure, as defined in § 761.2(dd). Section 761.2(hh) and TSCA section 6(e)(2)(C) define the term totally enclosed manner as "any manner which will ensure that any exposure of human beings or the environment to a polychlorinated biphenyl will be insignificant. . . ." Since any exposure to PCBs is found to be a significant exposure, a totally enclosed manner is a manner that results in no exposure of humans or the environment to PCBs. The following activities are considered totally enclosed: distribution in commerce and use (except servicing) of intact, non-leaking PCB Transformers or PCB-Contaminated Transformers (except those used in railroad locomotives or self-propelled cars); distribution in commerce and use (except servicing) of intact, non-leaking PCB electromagnets; distribution in commerce and use of intact, non-leaking PCB Capacitors; and processing, distribution in commerce, and use of PCB Equipment containing an intact, non-leaking PCB Capacitor.

(a) No person may process, distribute in commerce, or use any PCB or PCB Item in any manner other than in a totally enclosed manner within the United States or export any such PCB or PCB Item from the United States unless authorized under § 761.31 of this Subpart. Section 761.30(a) is superseded by § 761.30(c) for processing and distribution in commerce of PCBs and PCB Items on the dates when that section becomes effective.

(b) No person may manufacture PCBs for use within the United States or manufacture PCBs for export from the United States without an exemption except that:

(1) PCBs or PCB Items may be imported for purposes of disposal until May 1, 1980, provided that the disposal is in accordance with § 761.10; and

(2) PCBs or PCB Items may be exported for disposal until May 1, 1980, in accordance with the requirements of § 761.30(c)(3).

(c) Effective July 1, 1979, no person may process or distribute in commerce any PCB or PCB Item for use within the United States or for export from the United States without an exemption except that:

(1) PCBs or PCB Items sold before July 1, 1979, for purposes other than resale may be distributed in commerce only in a totally enclosed manner after that date;

(2) PCBs or PCB Items may be processed and distributed in commerce in compliance with the requirements of this Part for purposes of disposal in accordance with the requirements of § 761.10;

(3) PCBs or PCB Items may be exported for disposal until May 1, 1980, if an export notice is submitted at least thirty (30) days before the first shipment in any calendar year leaves the customs territory of the United States. Export notices must be submitted to the Document Control Officer (TS-793), Office of Toxic Substances, U.S. Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20460. The generator of the PCB waste material intended for disposal, or an agent acting on his behalf, must certify to the best of his knowledge and belief that the information is complete and accurate. Each notice should contain the following information:

(i) Name, company name, address, and telephone number of the owner of the PCB waste material to be exported and the name and address of any person or agent acting on his behalf;

(ii) Estimated quantity of wastes to be shipped during the calendar year and the estimated number of shipments to be made and the dates when such shipments are expected to leave the customs territory of the United States;

(iii) Description of the PCBs or PCB Items being exported;

(iv) Country(s) of destination for the shipments;

(v) Name and address of facility(s) receiving the shipment and person(s) responsible for receiving the shipment(s).

(vi) Method(s) of disposal and precautions taken to control release into the environment.

(vii) No less than 30 days after the end of each calendar quarter (March 31, June 30, September 30, and December 31) during which PCBs were exported for disposal, each person exporting the PCBs must submit a report to the Document Control Officer (TS-793), Office of Toxic Substances, U.S. Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20460. The report shall list the quantity of PCB wastes in each shipment made during the quarter and include the date when each shipment left the customs territory of the United States and the information specified in subparagraphs (i) and (iii) through (vi) above. If the quantity of wastes shipped during the calendar year exceeds by 25 percent or more the estimated quantities reported in (ii) above, a special export notice must be submitted to the Document Control Officer (TS-793) at the address given in paragraph (3) at least 30 days before any additional shipments leave the customs territory of the United States and the notice shall include the information specified in subparagraphs (i) through (vi) above.

(viii) Any person expecting to export PCB wastes for disposal in calendar year 1980 must submit an export notice at least thirty (30) days before the first shipment leaves the customs territory of the United States to the Document Control Officer (TS-793) at the address given in paragraph (3), and the notice shall contain the information listed in subparagraphs (i) through (vi).

(d) The use of waste oil that contains any detectable concentration of PCB as a sealant, coating, or dust control agent is prohibited. Prohibited uses include, but are not limited to, road oiling, general dust control, use as a pesticide or herbicide carrier, and use as a rust preventative on pipes.

§ 761.31 Authorizations.

The following non-totally enclosed PCB activities are authorized pursuant to § 6(e)(2)(B) of TSCA:

(a) *Servicing Transformers (Other Than Railroad Transformers).* PCBs may be processed, distributed in commerce, and used for the purposes of servicing including rebuilding transformers (other than transformers for railroad locomotives and self-propelled railroad cars) in a manner other than a totally enclosed manner until July 1, 1984, subject to the following conditions:

(1) Regardless of its PCB concentration, dielectric fluids containing less than 500 ppm PCB that are mixed with fluids that contain 500 ppm or greater PCB must not be used as dielectric fluid in any transformer. Dielectric fluid from PCB-Contaminated Transformers may be assumed to have less than 500 ppm PCBs.

(2) PCB-Contaminated Transformers (as defined in § 761.2(z)) may only be serviced (including rebuilding) with dielectric fluid containing less than 500 ppm PCB.

(3) Any servicing (including rebuilding) of PCB Transformers (as defined in § 761.2(y)) that requires the removal of the transformer coil from the transformer casing is prohibited. PCB Transformers may be topped off with PCB dielectric fluid.

(4) PCBs removed during servicing of a PCB Transformer or PCB-Contaminated Transformer or during rebuilding of a PCB-Contaminated Transformer must be captured and either reused as dielectric fluid or disposed of in accordance with the requirements of Subpart B. PCBs from PCB Transformers must not be mixed with or added to dielectric fluid from PCB-Contaminated Transformers.

(5) A PCB Transformer may be converted to a PCB-Contaminated Transformer by draining, refilling, and otherwise servicing the transformer with non-PCB dielectric fluid so that after a minimum of three months of in-service use subsequent to the last servicing conducted for the purpose of reducing the PCB concentration in the transformer, the transformer's dielectric fluid contains less than 500 ppm PCB (on a dry weight basis).

(6) Any PCB dielectric fluid that is on hand to service a PCB Transformer or a PCB-Contaminated Transformer must be stored in accordance with the storage for disposal requirements of Annex III (§ 761.42).

(7) After July 1, 1979, processing and distribution in commerce of PCBs for purposes of servicing transformers is permitted only for persons who are granted an exemption under TSCA section 6(e)(3)(B).

(b) *Use in and Servicing of Railroad Transformers.* PCBs may be used in transformers in railroad locomotives or railroad self-propelled cars ("railroad transformers") and may be processed and distributed in commerce for purposes of servicing these transformers in a manner other than a totally enclosed manner until July 1, 1984, subject to the following conditions:

(1) *Use Restrictions:*

(i) After January 1, 1982, use of railroad transformers that contain dielectric fluids with a PCB concentration greater than 60,000 ppm (6.0% on a dry weight basis) is prohibited;

(ii) After January 1, 1984, use of railroad transformers which contain dielectric fluids with a PCB concentration greater than 1000 ppm (0.10% on a dry weight basis) is prohibited;

(iii) The concentration of PCBs in the dielectric fluid contained in railroad transformers must be measured:

(A) Immediately upon completion of any authorized servicing of a railroad transformer conducted for the purpose of reducing the PCB concentration in the dielectric fluid in the transformer; and

(B) Between 12 and 24 months after each servicing conducted in accordance with subparagraph (A);

(C) The data obtained as a result of subparagraphs (A) and (B) above shall be retained until January 1, 1991.

(2) *Servicing Restrictions:*

(i) If the coil is removed from the casing of a railroad transformer (e.g., the transformer is rebuilt), after January 1, 1982, the railroad transformer may not be refilled with dielectric fluid containing a PCB concentration greater than 50 ppm;

(ii) After January 1, 1982, railroad transformers may only be serviced with dielectric fluid containing less than 60,000 ppm PCBs, except as provided in (i) above;

(iii) After January 1, 1984, railroad transformers may only be serviced with dielectric fluid containing less than 1000 ppm PCB, except as provided in (i) above;

(iv) Dielectric fluid may be filtered through activated carbon or otherwise industrially processed for the purpose of reducing the PCB concentration in the fluid;

(v) Any PCB dielectric fluid that is used to service PCB railroad transformers must be stored in accordance with the storage for disposal requirements of Annex III (§ 761.42);

(vi) After July 1, 1979, processing and distribution in commerce of PCBs for purposes of servicing railroad transformers is permitted only for persons who are granted an exemption under TSCA section 6(e)(3)(B).

(c) *Use in and Servicing of Mining Equipment.* PCBs may be used in mining equipment and may be processed and distributed in commerce for purposes of servicing mining equipment in a manner other than a totally enclosed manner until January 1, 1982, subject to the following conditions:

(1) PCBs may be added to motors in mining equipment in mines or mining areas until January 1, 1982;

(2) PCB motors in loader-type mining equipment must be rebuilt as air-cooled or other non-PCB-containing motors whenever the motor is returned to a service shop for servicing;

(3) PCB motors in continuous miner-type equipment may be rebuilt as PCB motors until January 1, 1980;

(4) Any PCBs that are on hand to service or repair mining equipment must be stored in accordance with the storage for disposal requirements of Annex III (§ 761.42);

(5) After July 1, 1979, processing and distribution in commerce of PCBs for purposes of servicing mining equipment is permitted only for persons who are granted an exemption under TSCA section 6(e)(3)(B).

(d) *Use in Heat Transfer Systems.* PCBs may be used in heat transfer systems in a manner other than a totally enclosed manner until July 1, 1984, subject to the following conditions:

(1) Each person who owns a heat transfer system that ever contained PCBs must test for the concentration of PCBs in the heat transfer fluid of such a system no later than November 1, 1979, and at least annually thereafter. All test sampling must be performed at least three months after the most recent fluid refilling. When a test shows that the PCB concentration is less than 50 ppm, testing under this subparagraph is no longer required;

(2) Within six (6) months of a test performed under subparagraph (1) that indicates that a system's fluid contains 50 ppm or greater PCB (0.005% on a dry weight basis), the system must be drained of the PCBs and refilled with fluid containing less than 50 ppm PCB. Topping-off with non-PCB heat transfer fluids to reduce PCB concentrations is permitted;

(3) After November 1, 1979, no heat transfer system that is used in the manufacture or processing of any food, drug, cosmetic, or device, as defined in § 201 of the Federal Food, Drug, and Cosmetic Act, may contain heat transfer fluid with 50 ppm or greater PCB (0.005% on a dry weight basis);

(4) Addition of PCBs to a heat transfer system is prohibited.

(5) Data obtained as a result of subparagraph (1) must be retained for five (5) years after the heat transfer system reaches 50 ppm PCB;

(e) *Use in Hydraulic Systems.* PCBs may be used in hydraulic systems and may be processed and distributed in commerce for purposes of filtering, distilling, or otherwise reducing the concentration of PCBs in hydraulic fluids in a manner other than a totally enclosed manner until July 1, 1984, subject to the following conditions:

(1) Each person who owns a hydraulic system that ever contained PCBs must test for the concentration of PCBs in the hydraulic fluid of each such system no later than November 1, 1979, and at least annually thereafter. All test sampling must be performed at least three months after the most recent fluid refilling. When a test shows that the PCB concentration is less than 50 ppm, testing under this subparagraph is no longer required;

(2) Within six (6) months of a test under subparagraph (1) that indicates that a system's fluid contains 50 ppm or greater PCB (0.005% on a dry weight basis), the system must be drained of the PCBs and refilled with fluid containing less than 50 ppm PCB. Topping-off with non-PCB hydraulic fluids to reduce PCB concentrations is permitted;

(3) Addition of PCBs to a hydraulic system is prohibited;

(4) Hydraulic fluid may be drained from a hydraulic system and filtered, distilled, or otherwise serviced in order to reduce the PCB concentration below 50 ppm;

(5) After July 1, 1979, processing and distribution in commerce of PCBs for purposes of servicing hydraulic systems is permitted only for persons who are granted an exemption under TSCA section 6(e)(3)(B);

(6) Data obtained as a result of subparagraph (1) above must be retained for five years after the hydraulic system reaches 50 ppm.

(f) *Use in Carbonless Copy Paper.* Carbonless copy paper containing PCBs may be used in a manner other than a totally enclosed manner indefinitely.

(g) *Pigments.* Diarylide and Phthalocyanin pigments that contain 50 ppm or greater PCB may be processed, distributed in commerce, and used in a manner other than a totally enclosed manner until January 1, 1982, except that after July 1, 1979, processing and distribution in commerce of diarylide or phthalocyanin pigments that contain 50 ppm or greater PCB is permitted only for persons who are granted an exemption under TSCA section 6(e)(3)(B).

(h) *Servicing Electromagnets.* PCBs may be processed, distributed in commerce, and used for the purpose of servicing electromagnets until July 1, 1984, in a manner other than a totally enclosed manner subject to the following requirements:

(1) PCBs removed during servicing must be captured and either returned to the electromagnet, reused as a dielectric fluid, or disposed of in accordance with Subpart B (§ 761.10);

(2) Servicing of PCB electromagnets (including rebuilding) which requires the removal of the coil from the casing is prohibited.

(3) Any PCBs that are on hand to service a PCB electromagnet must be stored in accordance with the storage for disposal requirements of Annex III (§ 761.42);

(4) After July 1, 1979, processing and distribution in commerce of PCBs for purposes of servicing electromagnets is permitted only for persons who are granted an exemption under TSCA section 6(e)(3)(B).

(i) *Use in Natural Gas Pipeline Compressors.* PCBs may be used in natural gas pipeline compressors until May 1, 1980, in a manner other than a totally enclosed manner.

(j) *Small Quantities for Research and Development.* PCBs may be processed, distributed in commerce, and used in small quantities for research and development, as defined in § 760.2(ee), in a manner other than a totally enclosed manner until July 1, 1984, except that after July 1, 1979, processing and distribution in commerce of PCBs in small quantities for research and development is permitted only for persons who have been granted an exemption under TSCA section 6(e)(3)(B).

(k) *Microscopy Mounting Medium.* PCBs may be processed, distributed in commerce, and used as a mounting medium in microscopy in a manner other than a totally enclosed manner until July 1, 1984, except that after July 1, 1979, processing and distribution in commerce of PCBs for purposes of use as a mounting medium in microscopy are permitted only for persons who are granted an exemption under TSCA section 6(e)(3)(B).

Subpart E—List of Annexes

Annex I

§ 761.40 Incineration.

(a) *Liquid PCBs.* An incinerator used for incinerating PCBs shall be approved by the Agency Regional Administrator pursuant to paragraph (d) of this section. The incinerator shall meet all of the requirements specified in subparagraph (1) through (9) of this paragraph, unless a waiver from these requirements is obtained pursuant to paragraph (d)(5) of this section. In addition, the incinerator shall meet any other requirements which may be prescribed pursuant to paragraph (d)(4) of this section.

(1) Combustion criteria shall be either of the following:

(i) Maintenance of the introduced liquids for a 2-second dwell time at 1200°C(±100°C) and 3 percent excess oxygen in the stack gas; or

(ii) Maintenance of the introduced liquids for a 1½ second dwell time at 1600°C(±100°C) and 2 percent excess oxygen in the stack gas.

(2) Combustion efficiency shall be at least 99.9 percent computed as follows:

$$\text{Combustion efficiency} = C_{CO_2}/C_{CO_2} + C_{CO} \times 100$$

where

C_{CO_2} = Concentration of carbon dioxide.
C_{CO} = Concentration of carbon monoxide.

(3) The rate and quantity of PCBs which are fed to the combustion system shall be measured and recorded at regular intervals of no longer than 15 minutes.

(4) The temperatures of the incineration process shall be continuously measured and recorded. The combustion temperature of the incineration process shall be based on either direct (pyrometer) or indirect (wall thermocouple-pyrometer correlation) temperature readings.

(5) The flow of PCBs to the incinerator shall stop automatically whenever the combustion temperature drops below the temperatures specified in subparagraph (1) of this paragraph.

(6) Monitoring of stack emission products shall be conducted:

(i) When an incinerator is first used for the disposal of PCBs under the provisions of this regulation;

(ii) When an incinerator is first used for the disposal of PCBs after the incinerator has been modified in a manner which may affect the characteristics of the stack emission products; and

(iii) At a minimum such monitoring shall be conducted for the following parameters: (a) O_2; (b) CO; (c) CO_2; (d) Oxides of Nitrogen (NO_x); (e) Hydrochloric Acid (HCl); (f) Total Chlorinated Organic Content (RCl); (g) PCBs; and (h) Total Particulate Matter.

(7) At a minimum monitoring and recording of combustion products and incineration operations shall be conducted for the following parameters whenever the incinerator is incinerating PCBs; (i) O_2; (ii) CO; and (iii) CO_2. The monitoring for O_2 and CO shall be continuous. The monitoring for CO_2 shall be periodic, at a frequency specified by the Regional Administrator.

(8) The flow of PCBs to the incinerator shall stop automatically when any one or more of the following conditions occur unless a contingency plan is submitted by the incinerator owner or operator and approved by the Regional Administrator and the contingency plan indicates what alternative measures the incinerator owner or operator would take if any of the following conditions occur:

(i) Failure of monitoring operations specified in subparagraph (7) of this paragraph;

(ii) Failure of the PCB rate and quantity measuring and recording equipment specified in subparagraph (3) of this paragraph; or

(iii) Excess oxygen falls below the percentage specified in subparagraph (1) of this paragraph.

(9) Water scrubbers shall be used for HCl control during PCB incineration and shall meet any performance requirements specified by the appropriate EPA Regional Administrator. Scrubber effluent shall be monitored and shall comply with applicable effluent or pretreatment standards, and any other State and Federal laws and regulations. An alternate method of HCl control may be used if the alternate method has been approved by the Regional Administrator. (The HCl neutralizing capability of cement kilns is considered to be an alternate method.)

(b) *Non-liquid PCBs.* An incinerator used for incinerating non-liquid PCBs, PCB Articles, PCB Equipment, or PCB Containers shall be approved by the Agency Regional Administrator pursuant to paragraph (d) of this section. The incinerator shall meet all of the requirements specified in subparagraphs (1) and (2) of this paragraph unless a waiver from these requirements is obtained pursuant to paragraph (d)(5) of this section. In addition, the incinerator shall meet any other requirements that may be prescribed pursuant to paragraph (d)(4) of this section.

(1) The mass air emissions from the incinerator shall be no greater than 0.001g PCB/kg of the PCB introduced into the incinerator.

(2) The incinerator shall comply with the provisions of § 761.40(a)(2), (3), (4), (6), (7), (8)(i) and (ii), and (9).

(c) *Maintenance of data and records.* All data and records required by this section shall be maintained in accordance with Annex VI—§ 761.45, Records and Monitoring.

(d) *Approval of incinerators.* Prior to the incineration of PCBs and PCB Items the owner or operator of an incinerator shall receive the written approval of the Agency Regional Administrator for the Region in which the incinerator is located. Such approval shall be obtained in the following manner:

(1) *Initial Report.* The owner or operator shall submit to the Regional administrator an initial report which contains:

(i) The location of the incinerator;

(ii) A detailed description of the incinerator including general site plans and design drawings of the incinerator;

(iii) Engineering reports or other information on the anticipated performance of the incinerator;

(iv) Sampling and monitoring equipment and facilities available;

(v) Waste volumes expected to be incinerated;

(vi) Any local, State, or Federal permits or approvals; and

(vii) Schedules and plans for complying with the approval requirements of this regulation.

(2) *Trial burn.* (i) Following receipt of the report described in subparagraph (1) of this paragraph, the Regional Administrator shall determine if a trial burn is required and notify the person who submitted the report whether a trial burn of PCBs and PCB Items must be conducted. The Regional Administrator may require the submission of any other information that the Regional Administrator finds to be reasonably necessary to determine the need for a trial burn. Such other information shall be restricted to the types of information required in subparagraph (1)(i) through (1)(vii) of this paragraph.

(ii) If the Regional Administrator determines that a trial burn must be held, the person who submitted the report described in subparagraph (1) of this paragraph shall submit to the Regional Administrator a detailed plan for conducting and monitoring the trial burn. At a minimum, the plan must include:

(A) Date trial burn is to be conducted;

(B) Quantity and type of PCBs and PCB Items to be incinerated;

(C) Parameters to be monitored and location of sampling points;

(D) Sampling frequency and methods and schedules for sample analyses; and

(E) Name, address, and qualifications of persons who will review analytical results and other pertinent data, and who will perform a technical evaluation of the effectiveness of the trial burn.

(iii) Following receipt of the plan described in subparagraph (2)(ii) of this paragraph, the Regional Administrator will approve the plan, require additions or modifications to the plan, or disapprove the plan. If the plan is disapproved, the Regional Administrator will notify the person who submitted the plan of such disapproval, together with the reasons why it is disapproved. That person may thereafter submit a new plan in accordance with subparagraph (2)(ii) of this paragraph. If the plan is approved (with any additions or modifications which the Regional Administrator may Prescribe), the Regional Administrator will notify the person who submitted the plan of the approval. Thereafter the trial burn shall take place at a date and time to be agreed upon between the Regional Administrator and the persons who submitted the plan.

(3) *Other information.* In addition to the information contained in the report and plan described in subparagraphs (1) and (2) of this paragraph, the Regional Administrator may require the owner or operator to submit any other information that the Regional Administrator finds to be reasonably necessary to determine whether an incinerator shall be approved.

Note.—The Regional Administrator will have available for review and inspection an Agency manual containing information on sampling methods and analytical procedures for the parameters required in § 761.40(a)(3), (4), (6), and (7) plus any other parameters he may determine to be appropriate. Owners or operators are encouraged to review this manual prior to submitting any report required in this Annex.

(4) *Contents of Approval.* (i) Except as provided in subparagraph (5) of this paragraph, the Regional Administrator may not approve an incinerator for the disposal of PCB and PCB Items unless he finds that the incinerator meets all of the requirements of paragraphs (a) and/or (b) of this section.

(ii) In addition to the requirements of paragraphs (a) and/or (b) of this section, the Regional Administrator may include in an approval any other requirements that the Regional Administrator finds are necessary to ensure that operation of the incinerator does not present an unreasonable risk of injury to health or the environment from PCBs. Such requirements may include a fixed period of time for which the approval is valid.

(5) *Waivers.* An owner or operator of the incinerator may submit evidence to the Regional Administrator that operation of the incinerator will not present an unreasonable risk of injury to health or the environment from PCBs, when one or more of the requirements of paragraphs (a) and/or (b) of this section are not met. On the basis of such evidence and any other available information, the Regional Administrator may in his discretion find that any requirement of paragraph (a) and (b) is

not necessary to protect against such a risk, and may waive the requirements in any approval for that incinerator. Any finding and waiver under this subparagraph must be stated in writing and included as part of the approval.

(6) *Persons Approved.* An approval will designate the persons who own and who are authorized to operate the incinerator, and will apply only to such persons, except as provided in paragraph (8) below.

(7) *Final Approval.* Approval of an incinerator will be in writing and signed by the Regional Administrator. The approval will state all requirements applicable to the approved incinerator.

(8) *Transfer of Property.* Any person who owns or operates an approved incinerator must notify EPA at least 30 days before transferring ownership in the incinerator or the property it stands upon, or transferring the right to operate the incinerator. The transferor must also submit to EPA, at least 30 days before such transfer, a notarized affidavit signed by the transferee which states that the transferee will abide by the transferor's EPA incinerator approval. Within 30 days of receiving such notification and affidavit, EPA will issue an amended approval substituting the transferee's name for the transferor's name, or EPA may require the transferee to apply for a new incinerator approval. In the latter case, the transferee must abide by the transferor's EPA approval until EPA issues the new approval to the transferee.

Annex II

§ 761.41 Chemical waste landfills.

(a) *General.* A chemical waste landfill used for the disposal of PCBs and PCB Items shall be approved by the Agency Regional Administrator pursuant to paragraph (c) of this section. The landfill shall meet all of the requirements specified in paragraph (b) of this section, unless a waiver from these requirements is obtained pursuant to paragraph (c)(4) of this section. In addition, the landfill shall meet any other requirements that may be prescribed pursuant to paragraph (c)(3) of this section.

(b) *Technical Requirements.* Requirements for chemical waste landfills used for the disposal of PCBs and PCB Items are as follows:

(1) *Soils.* The landfill site shall be located in thick, relatively impermeable formations such as large-area clay pans. Where this is not possible, the soil shall have a high clay and silt content with the following parameters:

(i) In-place soil thickness, 4 feet or compacted soil liner thickness, 3 feet;

(ii) Permeability (cm/sec), equal to or less than 1×10^{-7};

(iii) Percent soil passing No. 200 Sieve, >30;

(iv) Liquid Limit, >30; and

(v) Plasticity Index >15.

(2) *Synthetic Membrane Liners.* Synthetic membrane liners shall be used when, in the judgment of the Regional Administrator, the hydrologic or geologic conditions at the landfill require such a liner in order to provide at least a permeability equivalent to the soils in (1) above. Whenever a synthetic liner is used at a landfill site, special precautions shall be taken to insure that its integrity is maintained and that it is chemically compatible with PCBs. Adequate soil underlining and soil cover shall be provided to prevent excessive stress on the liner and to prevent rupture of the liner. The liner must have a minimum thickness of 30 mils.

(3) *Hydrologic Conditions.* The bottom of the landfill shall be above the historical high groundwater table as provided below. Floodplains, shorelands, and groundwater recharge areas shall be avoided. There shall be no hydraulic connection between the site and standing or flowing surface water. The site shall have monitoring wells and leachate collection. The bottom of the landfill liner system or natural in-place soil barrier shall be at least fifty feet from the historical high water table.

(4) *Flood Protection.* (i) If the landfill site is below the 100-year floodwater elevation, the operator shall provide surface water diversion dikes around the perimeter of the landfill site with a minimum height equal to two feet above the 100-year floodwater elevation.

(ii) If the landfill site is above the 100-year floodwater elevation, the operators shall provide diversion structures capable of diverting all of the surface water runoff from a 24-hour, 25-year storm.

(5) *Topography.* The landfill site shall be located in an area of low to moderate relief to minimize erosion and to help prevent landslides or slumping.

(6) *Monitoring Systems.* (i) *Water Sampling.* (A) For all sites receiving PCBs, the ground and surface water from the disposal site area shall be sampled prior to commencing operations under an approval provided in § 761.41(c) for use as baseline data.

(B) Any surface watercourse designated by the Regional Administrator using the authority provided in § 761.41(c)(3)(ii) shall be sampled at least monthly when the landfill is being used for disposal operations.

(C) Any surface watercourse designated by the Regional Administrator using the authority provided in § 761.41(c)(3)(ii) shall be sampled for a time period specified by the Regional Administrator on a frequency of no less than once every six months after final closure of the disposal area.

(ii) *Groundwater Monitor Wells.* (A) If underlying earth materials are homogenous, impermeable, and uniformly sloping in one direction, only three sampling points shall be necessary. These three points shall be equally spaced on a line through the center of the disposal area and extending from the area of highest water table elevation to the area of the lowest water table elevation on the property.

(B) All monitor wells shall be cased and the annular space between the monitor zone (zone of saturation) and the surface shall be completely backfilled with Portland cement or an equivalent material and plugged with Portland cement to effectively prevent percolation of surface water into the well bore. The well opening at the surface shall have a removable cap to provide access and to prevent entrance of rainfall or stormwater runoff. The well shall be pumped to remove the volume of liquid initially contained in the well before obtaining a sample for analysis. The discharge shall be treated to meet applicable State or Federal discharge standards or recycled to the chemical waste landfill.

(iii) *Water Analysis.* As a minimum, all samples shall be analyzed for the following parameters, and all data and records of the sampling and analysis shall be maintained as required in Annex VI—§ 761.45(d)(1). Sampling methods and analytical procedures for these parameters shall comply with those specified in 40 CFR Part 136 as amended in 41 FR 52779 on December 1, 1976.

(A) PCBs.

(B) pH.

(C) Specific Conductance.

(D) Chlorinated Organics.

(7) *Leachate Collection.* A leachate collection monitoring system shall be installed above the chemical waste landfill. Leachate collection systems shall be monitored monthly for quantity and physicochemical characteristics of leachate produced. The leachate should be either treated to acceptable limits for discharge in accordance with a State or Federal permit or disposed of by another State or Federally approved method. Water analysis shall be conducted as

provided in subparagraph (6) (iii) of this paragraph. Acceptable leachate monitoring/collection systems shall be any of the following designs, unless a waiver is obtained pursuant to paragraph (c)(4) of this section.

(i) Simple Leachate Collection. This system consists of a gravity flow drainfield installed above the waste disposal facility liner. This design is recommended for use when semi-solid or leachable solid wastes are placed in a lined pit excavated into a relatively thick, unsaturated, homogenous layer of low permeability soil.

(ii) Compound Leachate Collection. This system consists of a gravity flow drainfield installed above the waste disposal facility liner and above a secondary installed liner. This design is recommended for use when semi-liquid or leachable solid wastes are placed in a lined pit excavated into relatively permeable soil.

(ii) Suction Lysimeters. This system consists of a network of porous ceramic cups connected by hoses/tubing to a vacuum pump. The porous ceramic cups or suction lysimeters are installed along the sides and under the bottom of the waste disposal facility liner. This type of system works best when installed in a relatively permeable unsaturated soil immediately adjacent to the bottom and/or sides of the disposal facility.

(8) *Chemical Waste Landfill Operations.* (i) PCBs and PCB Items shall be placed in a landfill in a manner that will prevent damage to containers or articles. Other wastes placed in the landfill that are not chemically compatible with PCBs and PCB Items including organic solvents shall be segregated from the PCBs throughout the waste handling and disposal process.

(ii) An operation plan shall be developed and submitted to the Regional Administrator for approval as required in paragraph (c) of this section. This plan shall include detailed explanations of the procedures to be used for recordkeeping, surface water handling procedures, excavation and backfilling, waste segregation burial coordinates, vehicle and equipment movement, use of roadways, leachate collection systems, sampling and monitoring procedures, monitoring wells, environmental emergency contingency plans, and security measures to protect against vandalism and unauthorized waste placements. EPA guidelines entitled "Thermal Processing and Land Disposal of Solid Waste" (39 FR 29337, August 14, 1974) are a useful reference in preparation of this plan. If the facility is to be used to dispose of liquid wastes containing between 50 ppm and 500 ppm PCB, the operations plan must include procedures to determine that liquid PCBs to be disposed of at the landfill do not exceed 500 ppm PCB and meaures to prevent the migration of PCBs from the landfill. Bulk liquids not exceeding 500 ppm PCBs may be disposed of provided such waste is pretreated and/or stabilized (e.g., chemically fixed, evaporated, mixed with dry inert absorbant) to reduce its liquid content or increase its solid content so that a non-flowing consistency is achieved to eliminate the presence of free liquids prior to final disposal in a landfill. PCB Container of liquid PCBs with a concentration between 50 and 500 ppm PCB may be disposed of if each container is surrounded by an amount of inert sorbant material capable of absorbing all of the liquid contents of the container.

(iii) Ignitable wastes shall not be disposed of in chemical waste landfills. Liquid ignitable wastes are wastes that have a flash point less than 60 degrees C (140 degrees F) as determined by the following method or an equivalent method: Flash point of liquids shall be determined by a Pensky-Martens Closed Cup Tester, using the protocol specified in ASTM Standard D-93, or the Setaflash Closed Tester using the protocol specified in ASTM Standard D-3278.

(iv) Records shall be maintained for all PCB disposal operations and shall include information on the PCB concentration in liquid wastes and the three dimensional burial coordinates for PCBs and PCB Items. Additional records shall be developed and maintained as required in Annex VI.

(9) *Supporting Facilities.* (i) A six foot woven mesh fence, wall, or similar device shall be placed around the site to prevent unauthorized persons and animals from entering.

(ii) Roads shall be maintained to and within the site which are adequate to support the operation and maintenance of the site without causing safety or nuisance problems or hazardous conditions.

(iii) The site shall be operated and maintained in a manner to prevent safety problems or hazardous conditions resulting from spilled liquids and windblown materials.

(c) *Approval of Chemical Waste Landfills.* Prior to the disposal of any PCBs and PCB Items in a chemical waste landfill, the owner or operator of the landfill shall receive written approval of the Agency Regional Administrator for the Region in which the landfill is located. The approval shall be obtained in the following manner:

(1) *Initial Report.* The owner or operator shall submit to the Regional Administrator an initial report which contains:

(i) The location of the landfill;

(ii) A detailed description of the landfill including general site plans and design drawings;

(iii) An engineering report describing the manner is which the landfill complies with the requirements for chemical waste landfills specified in paragraph (b) of this section;

(iv) Sampling and monitoring equipment and facilities available;

(v) Expected waste volumes of PCBs;

(vi) General description of waste materials other than PCBs that are expected to be disposed of in the landfill;

(vii) Landfill operations plan as required in paragraph (b) of this section;

(viii) Any local, State, or Federal permits or approvals; and

(ix) Any schedules or plans for complying with the approval requirements of these regulations.

(2) *Other Information.* In addition to the information contained in the report described in subparagraph (1) of this paragraph, the Regional Administrator may require the owner or operator to submit any other information that the Regional Administrator finds to be reasonably necessary to determine whether a chemical waste landfill should be approved. Such other information shall be restricted to the types of information required in subparagraphs (1)(i) through (1)(ix) of this paragraph.

(3) *Contents of Approval.* (i) Except as provided in subparagraph (4) of this paragraph the Regional Administrator may not approve a chemical waste landfill for the disposal of PCBs and PCB Items, unless he finds that the landfill meets all of the requirements of paragraph (b) of this Annex.

(ii) In addition to the requirements of paragraph (b) of this section, the Regional Administrator may include in an approval any other requirements or provisions that the Regional Administrator finds are necessary to ensure that operation of the chemical waste landfill does not present an unreasonable risk of injury to health or the environment from PCBs. Such provisions may include a fixed period of time for which the approval is valid.

The approval may also include a stipulation that the operator of the chemical waste landfill report to the Regional Administrator any instance when PCBs are detectable during monitoring activities conducted pursuant to paragraph (b)(6) of this section.

(4) *Waivers.* An owner or operator of a chemical waste landfill may submit evidence to the Regional Administrator that operation of the landfill will not present an unreasonable risk of injury to health or the environment from PCBs when one or more of the requirements of paragraph (b) of this section are not met. On the basis of such evidence and any other available information, the Regional Administrator may in his discretion find that one or more of the requirements of § 761.41(b) is not necessary to protect against such a risk and may waive the requirements in any approval for that landfill. Any finding and waiver under this paragraph will be stated in writing and included as part of the approval.

(5) *Persons Approved.* Any approval will designate the persons who own and who are authorized to operate the chemical waste landfill, and will apply only to such persons, except as provided by paragraph (7) below.

(6) *Final Approval.* Approval of a chemical waste landfill will be in writing and will be signed by the Regional Administrator. The approval will state all requirements applicable to the approved landfill.

(7) *Transfer of Property.* Any person who owns or operates an approved chemical waste landfill must notify EPA at least 30 days before transferring ownership in the property or transferring the right to conduct the chemical waste landfill operation. The transferor must also submit to EPA, at least 30 days before such transfer, a notarized affidavit signed by the transferee which states that the transferee will abide by the transferor's EPA chemical waste landfill approval. Within 30 days of receiving such notification and affidavit, EPA will issue an amended approval substituting the transferee's name for the transferor's name, or EPA may require the transferee to apply for a new chemical waste landfill approval. In the latter case, the transferee must abide by the transferor's EPA approval until EPA issues the new approval to the transferee.

Annex III

§ 761.42 Storage for disposal.

(a) Any PCB Article or PCB Container stored for disposal before January 1, 1983, shall be removed from storage and disposed of as required by this Part before January 1, 1984. Any PCB Article or PCB Container stored for disposal after January 1, 1983, shall be removed from storage and disposed of as required by Subpart B within one year from the date when it was first placed into storage.

(b) Except as provided in paragraph (c) of this section, after July 1, 1978, owners or operators of any facilities used for the storage of PCBs and PCB Items designated for disposal shall comply with the following requirements:

(1) The facilities shall meet the following criteria:

(i) Adequate roof and walls to prevent rain water from reaching the stored PCBs and PCB Items;

(ii) An adequate floor which has continuous curbing with a minimum six inch high curb. The floor and curbing must provide a containment volume equal to at least two times the internal volume of the largest PCB Article or PCB Container stored therein or 25 percent of the total internal volume of all PCB Articles or PCB Containers stored therein, whichever is greater;

(iii) No drain valves, floor drains, expansion joints, sewer lines, or other openings that would permit liquids to flow from the curbed area;

(iv) Floors and curbing constructed of continuous smooth and impervious materials, such as Portland cement concrete or steel, to prevent or minimize penetration of PCBs; and

(v) Not located at a site that is below the 100-year flood water elevation.

(c)(1) The following PCB Items may be stored temporarily in an area that does not comply with the requirements of paragraph (b) for up to thirty days from the date of their removal from service, provided that a notation is attached to the PCB Item or a PCB Container (containing the item) indicating the date the item was removed from service:

(i) Non-leaking PCB Articles and PCB Equipment;

(ii) Leaking PCB Articles and PCB Equipment if the PCB Items are placed in a non-leaking PCB Container that contains sufficient sorbent materials to absorb any liquid PCBs remaining in the PCB Items;

(iii) PCB Containers containing non-liquid PCBs such as contaminated soil, rags, and debris; and

(iv) PCB Containers containing liquid PCBs at a concentration between 50 and 500 ppm, provided a Spill Prevention, Control and Countermeasure Plan has been prepared for the temporary storage area in accordance with 40 CFR 112. In addition, each container must bear a notation that indicates that the liquids in the drum do not exceed 500 ppm PCB.

(2) Non-leaking and structurally undamaged PCB Large High Voltage Capacitors and PCB-Contaminated Transformers that have not been drained of free flowing dielectric fluid may be stored on pallets next to a storage facility that meets the requirements of paragraph (b) until January 1, 1983. PCB-Contaminated Transformers that have been drained of free flowing dielectric fluid are not subject to the storage provisions of Annex III. Storage under this subparagraph will be permitted only when the storage facility has immediately available unfilled storage space equal to 10 percent of the volume of capacitors and transformers stored outside the facility. The capacitors and transformers temporarily stored outside the facility shall be checked for leaks weekly.

(3) Any storage area subject to the requirements of paragraph (b) or subparagraph (c)(1) of this section shall be marked as required in Subpart C—§ 761.20(a)(10).

(4) No item of movable equipment that is used for handling PCBs and PCB Items in the storage facilities and that comes in direct contact with PCBs shall be removed from the storage facility area unless it has been decontaminated as specified in Annex IV, § 761.43.

(5) All PCB Articles and PCB Containers in storage shall be checked for leaks at least once every 30 days. Any leaking PCB Articles and PCB Containers and their contents shall be transferred immediately to properly marked non-leaking containers. Any spilled or leaked materials shall be immediately cleaned up, using sorbents or other adequate means, and the PCB-contaminated materials and residues shall be disposed of in accordance with § 761.10(a)(4).

(6) Except as provided in subparagraph (7) below, any container used for the storage of liquid PCBs shall comply with the Shipping Container Specification of the Department of Transportation (DOT), 49 CFR 178.80 (Specification 5 container without removable head), 178.82 (Specification 5B container without removable head), 178.102 (Specification 6D overpack with Specification 2S(§ 178.35) or 2SL(§ 178.35a) polyethylene containers) or 178.116 (Specification 17E container). Any container used for the storage of non-liquid PCBs shall comply with the specifications of 49 CFR 178.80 (Specification 5 container), 178.82 (Specification 5B container) or 178.115 (Specification 17C container). As an alternate, containers larger than those specified in DOT Specifications 5, 5B, or 17C may be used for non-liquid PCBs if the containers are designed and constructed in a manner that will

provide as much protection against leaking and exposure to the environment as the DOT Specification containers, and are of the same relative strength and durability as the DOT Specification containers.

(7) Storage containers for liquid PCBs can be larger than the containers specified in (6) above provided that:

(i) The containers are designed, constructed, and operated in compliance with Occupational Safety and Health Standards, 29 CFR 1910.106, *Flammable and combustible liquids.* Before using these containers for storing PCBs, the design of the containers must be reviewed to determine the effect on the structural safety of the containers that will result from placing liquids with the specific gravity of PCBs into the containers (see 29 CFR 1910.106(b)(i)(f)).

(ii) The owners or operators of any facility using containers described in (i) above shall prepare and implement a Spill Prevention Control and Countermeasure (SPCC) Plan as described in 40 CFR 112. In complying with 40 CFR 112, the owner or operator shall read "oil(s)" as "PCB(s)" whenever it appears. The exemptions for storage capacity, 40 CFR 112.1(d)(2), and the amendment of SPCC plans by the Regional Administrator, 40 CFR 112.4, shall not apply unless some fraction of the liquids stored in the container are oils as defined by section 311 of the Clean Water Act.

(8) PCB Articles and PCB Containers shall be dated on the article or container when they are placed in storage. The storage shall be managed so that the PCB Articles and PCB Containers can be located by the date they entered storage. Storage containers provided in subparagraph (7) above shall have a record that includes for each batch of PCBs the quantity of the batch and date the batch was added to the container. The record shall also include the date, quantity, and disposition of any batch of PCBs removed from the container.

(9) Owners or operators of storage facilities shall establish and maintain records as provided in Annex VI.

Annex IV

§ 761.43 Decontamination.

(a) Any PCB Container to be decontaminated shall be decontaminated by flushing the internal surfaces of the container three times with a solvent containing less than 50 ppm PCB. The solubility of PCBs in the solvent must be five percent or more by weight. Each rinse shall use a volume of the normal diluent equal to approximately ten (10) percent of the PCB Container capacity. The solvent may be reused for decontamination until it contains 50 ppm PCB. The solvent shall then be disposed of as a PCB in accordance with § 761.10(a). Non-liquid PCBs resulting from the decontamination procedures shall be disposed of in accordance with the provisions of § 761.10(a)(4).

(b) Movable equipment used in storage areas shall be decontaminated by swabbing surfaces that have contacted PCBs with a solvent meeting the criteria of paragraph (a) of this section.

Note.—Precautionary measures should be taken to ensure that the solvent meets safety and health standards as required by applicable Federal regulations.

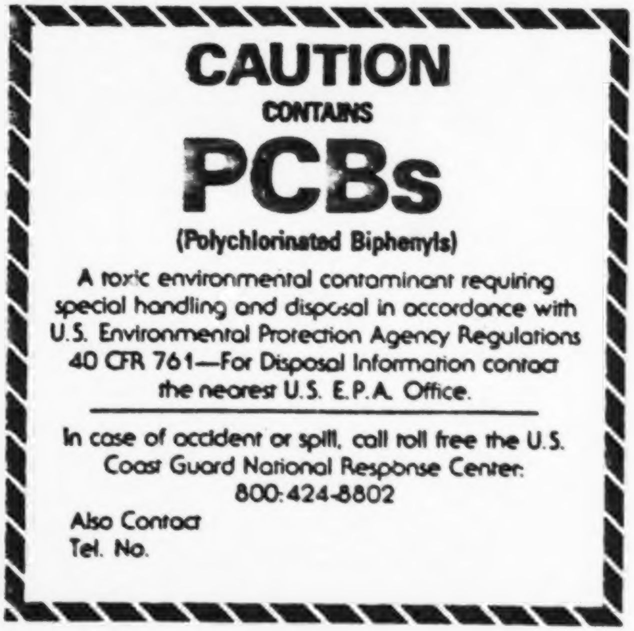
Annex V

§ 761.44 Marking formats.

The following formats shall be used for marking:

(a) *Large PCB Mark—M_L*. Mark M_L shall be as shown in Figure 1, letters and striping on a white or yellow background and shall be sufficiently durable to equal or exceed the life (including storage for disposal) of the PCB Article, PCB Equipment, or PCB Container. The size of the mark shall be at least 15.25 cm (6 inches) on each side. If the PCB Article or PCB Equipment is too small to accommodate this size, the mark may be reduced in size proportionately down to a minimum of 5 cm (2 inches) on each side.

(b) *Small PCB Mark—M_s*. Mark M_s shall be as shown in Figure 2, letters and striping on a white or yellow background, and shall be sufficiently durable to equal or exceed the life (including storage for disposal) of the PCB Article, PCB Equipment, or PCB Container. The mark shall be a rectangle 2.5 by 5 cm (1 inch by 2 inches). If the PCB Article or PCB Equipment is too small to accommodate this size, the mark may be reduced in size proportionately down to a minimum of 1 by 2 cm (.4 by .8 inches).



CAUTION

CONTAINS

PCBs

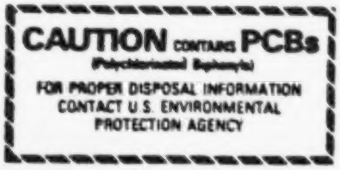
(Polychlorinated Biphenyls)

A toxic environmental contaminant requiring special handling and disposal in accordance with U.S. Environmental Protection Agency Regulations 40 CFR 761—For Disposal Information contact the nearest U.S. E.P.A. Office.

In case of accident or spill, call toll free the U.S. Coast Guard National Response Center:
800:424-8802

Also Contact
Tel. No.

Figure 1



CAUTION CONTAINS PCBs

(Polychlorinated Biphenyls)

FOR PROPER DISPOSAL INFORMATION CONTACT U.S. ENVIRONMENTAL PROTECTION AGENCY

Figure 2

Annex VI

§ 761.45 Records and monitoring.

(a) *PCBs and PCB Items in service or projected for disposal.* Beginning July 2, 1978, each owner or operator of a facility using or storing at one time at least 45 kilograms (99.4 pounds) of PCBs contained in PCB Container(s) or one or more PCB Transformers, or 50 or more PCB Large High or Low Voltage Capacitors shall develop and maintain records on the disposition of PCBs and PCB Items. These records shall form the basis of an annual document prepared for each facility by July 1 covering the previous calendar year. Owners or operators with one or more facilities that use or store PCBs and PCB Items in the quantities described above may maintain the records and documents at one of the facilities that is normally occupied for 8 hours a day, provided the identity of this facility is available at each facility using or storing PCBs and PCB Items. The records and documents shall be maintained for at least five years after the facility ceases using or storing PCBs and PCB Items in the prescribed quantities. The following information for each facility shall be included in the annual document:

(1) The dates when PCBs and PCB Items are removed from service, are placed into storage for disposal, and are placed into transport for disposal. The quantities of the PCBs and PCB Items shall be indicated using the following breakdown:

(i) Total weight in kilograms of any PCBs and PCB Items in PCB Containers including the identification of container contents such as liquids and capacitors;

(ii) Total number of PCB Transformers and total weight in kilograms of any PCBs contained in the transformers; and

(iii) Total number of PCB Large High or Low Voltage Capacitors.

(2) For PCBs and PCB Items removed from service, the location of the initial disposal or storage facility and the name of the owner or operator of the facility.

(3) Total quantities of PCBs and PCB Items remaining in service at the end of the calendar year using the following breakdown:

(i) Total weight in kilograms of any PCBs and PCB Items in PCB Containers, including the identification of container contents such as liquids and capacitors;

(ii) Total number of PCB Transformers and total weight in kilograms of any PCBs contained in the transformers; and

(iii) Total number of PCB Large High or Low Voltage Capacitors.

(b) *Disposal and storage facilities.* Each owner or operator of a facility (including high efficiency boiler operations) used for the storage or disposal of PCBs and PCB Items shall by July 1, 1979 and each July 1 thereafter prepare and maintain a document that includes the information required in subparagraphs (1) thru (4) below for PCBs and PCB Items that were handled at the facility during the previous calendar year. The document shall be retained at each facility for at least 5 years after the facility is no longer used for the storage or disposal of PCBs and PCB Items except that in the case of chemical waste landfills, the document shall be maintained at least 20 years after the chemical waste landfill is no longer used for the disposal of PCBs and PCB Items. The documents shall be available at the facility for inspection by authorized representatives of the Environmental Protection Agency. If the facility ceases to be used for PCB storage or disposal, the owner or operator of such facility shall notify within 60 days the EPA Regional Administrator of the region in which the facility is located that the facility has ceased storage or disposal operations. The notice shall specify where the documents that are required to be maintained by this paragraph are located. The following information shall be included in each document:

(1) The date when any PCBs and PCB Items were received by the facility during the previous calendar year for storage or disposal, and identification of the facility and the owner or operator of the facility from whom the PCBs were received;

(2) The date when any PCBs and PCB Items were disposed of at the disposal facility or transferred to another disposal or storage facility, including the identification of the specific types of PCBs and PCB Items that were stored or disposed of;

(3) A summary of the total weight in kilograms of PCBs and PCB Articles in containers and the total weight of PCBs contained in PCB Transformers, that have been handled at the facility during the previous calendar year. This summary shall provide totals of the above PCBs and PCB Items which have been:

(i) Received during the year;

(ii) Transferred to other facilities during the year; and

(iii) Retained at the facility at the end of the year. In addition the contents of PCB Containers shall be identified. When PCB Containers and PCBs contained in a transformer are transferred to other storage or disposal facilities, the identification of the facility to which such PCBs and PCB Items were transferred shall be included in the document.

(4) Total number of any PCB Articles or PCB Equipment not in PCB Containers, received during the calendar year, transferred to other storage or disposal facilities during the calendar year, or remaining on the facility site at the end of the calendar year. The identification of the specific types of PCB Articles and PCB Equipment received, transferred, or remaining on the facility site shall be indicated. When PCB Articles and PCB Equipment are transferred to other storage or disposal facilities, the identification of the facility to which the PCB Articles and PCB Equipment were transferred must be included.

Note.—Any requirements for weights in kilograms of PCBs may be calculated values if the internal volume of containers and transformers is known and included in the reports, together with any assumptions on the density of the PCBs contained in the containers or transformers.

(c) *Incineration facilities.* Each owner or operator of a PCB incinerator facility shall collect and maintain for a period of 5 years from the date of collection the following information, in addition to the information required in paragraph (b) of this section:

(1) When PCBs are being incinerated, the following continuous and short-interval data:

(i) Rate and quantity of PCBs fed to the combustion system as required in Annex I—§ 761.40(a)(3);

(ii) Temperature of the combustion process as required in Annex I—§ 761.40(a)(4); and

(iii) Stack emission product to include O_2, CO, and CO_2 as required in Annex I—§ 761.40(a)(7).

(2) When PCBs are being incinerated, data and records on the monitoring of stack emissions as required in Annex I—§ 761.40(a)(6).

(3) Total weight in kilograms of any solid residues generated by the incineration of PCBs and PCB Items during the calendar year, the total weight in kilograms of any solid residues disposed of by the facility in chemical waste landfills, and the total weight in kilograms of any solid residues remaining on the facility site.

(4) When PCBs and PCB Items are being incinerated, additional periodic data shall be collected and maintained as specified by the Regional Administrator pursuant to § 761.40(d)(4).

(5) Upon any suspension of the operation of any incinerator pursuant to § 761.40(a)(8), the owner or operator of such an incinerator shall prepare a document. The document shall, at a minimum, include the date and time of the suspension and an explanation of the circumstances causing the suspension of operation. The document shall be sent to the appropriate Regional Administrator within 30 days of any such suspension.

(d) *Chemical waste landfill facilities.* Each owner or operator of a PCB chemical waste landfill facility shall collect and maintain until at least 20 years after the chemical waste landfill is no longer used for the disposal of PCBs the following information in addition to the information required in paragraph (b) of this section:

(1) Any water analysis obtained in compliance with § 761.41(b)(6)(iii); and

(2) Any operations records including burial coordinates of wastes obtained in compliance with § 761.41(b)(8)(ii).

(e) *High efficiency boiler facilities.* Each owner or operator of a high efficiency boiler used for the disposal of liquids between 50 and 500 ppm PCB shall collect and maintain for a period of 5 years the following information, in addition to the information required in paragraph (b) of this section:

(1) For each month PCBs are burned in the boiler the carbon monoxide and excess oxygen data required in § 761.10(a)(2)(iii)(A)(*8*) and § 761.10(a)(3)(iii)(A)(*8*);

(2) The quantity of PCBs burned each month as required in § 761.10(a)(2)(iii)(A)(*7*) and § 761.10(a)(3)(iii)(A)(*7*); and

(3) For each month PCBs (other than mineral oil dielectric fluid) are burned, chemical analysis data of the waste as required in § 761.10(a)(3)(iii)(B)(*6*).

(f) *Retention of Special Records by Storage and Disposal Facilities.* In addition to the information required to be maintained under paragraphs (b), (c), (d) and (e) of this section, each owner or operator of a PCB storage or disposal facility (including high efficiency boiler operations) shall collect and maintain for the time period specified in paragraph (b) of this section the following data:

(1) All documents, correspondence, and data that have been provided to the owner or operator of the facility by any State or local government agency and that pertain to the storage or disposal of PCBs and PCB Items at the facility.

(2) All documents, correspondence, and data that have been provided by the owner or operator of the facility to any State or local government agency and that pertain to the storage or disposal of PCBs and PCB Items at the facility.

(3) Any applications and related correspondence sent by the owner or operator of the facility to any local, State, or Federal authorities in regard to waste water discharge permits, solid waste permits, building permits, or other permits or authorizations such as those required by Annex I—§ 761.40(d) and Annex II—§ 761.41(c).

[FR Doc. 79-16[illegible] Filed 5-30-79; 8:45 am]

BILLING CODE 6560-01-M

---

40 CFR Part 750

[FRL 1227-5]

Procedures for Rulemaking Under Section 6 of the Toxic Substances Control Act; Interim Procedural Rules for Exemptions From the Polychlorinated Biphenyl (PCB) Processing and Distribution in Commerce Prohibitions

AGENCY: Environmental Protection Agency.

ACTION: Interim procedures for filing and processing petitions for exemptions from the PCB processing and distribution in commerce prohibitions under section 6(e)(3)(B) of the Toxic Substances Control Act (TSCA).

SUMMARY: Section 6(e)(3)(B) of TSCA allows EPA to grant, by rule, exemptions from the prohibitions on manufacturing, processing, and distribution in commerce of PCBs established pursuant to section 6(e)(3)(A) of TSCA. Since the PCB processing and distribution in commerce prohibitions will become effective July 1, 1979, EPA wishes to inform affected parties of the procedures that will be followed for the filing and processing of petitions for exemptions from the processing and distribution in commerce bans imposed by section 6(e)(3)(A)(ii) of TSCA. As this notice is strictly procedural, notice and public comment are unnecessary, and it is effective upon publication.

DATE: Petitions for exemptions from the 1979 processing and distribution in commerce prohibitions must be received by July 2, 1979.

ADDRESS: Petitions, preferably in triplicate, are to be sent to: Document Control Officer, (TS-793), Office of Toxic Substances, U.S. Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20460, Attn.: Document No. OTS/066002(PCB/PDE).

FOR FURTHER INFORMATION CONTACT: John B. Ritch, Jr., Director, Office of Industry Assistance, Office of Toxic Substances, (TS-799), Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20460. Call the toll free number (800) 424-9065 (in Washington, D.C., 554-1404).

SUPPLEMENTARY INFORMATION: Elsewhere in today's Federal Register, the final PCB Ban Rule is promulgated. The PCB Ban Rule implements the PCB manufacturing, processing, distribution in commerce, and use prohibitions of section 6(e) of TSCA. On November 1, 1978 (43 FR 50905), EPA published a notice similar to this one which provided an opportunity for the filing of petitions for exemptions from the PCB manufacturing prohibition, which ban is effective July 2, 1979. The PCB processing and distribution in commerce prohibitions are effective July 1, 1979. Section 6(e)(3)(B) provides an opportunity for affected persons to petition for an exemption from the prohibitions on processing and distribution in commerce of PCBs. Accordingly, EPA is issuing these procedures to describe the required contents of petitions, who may submit a class petition, and the procedures that EPA will follow in processing petitions for exemptions from the PCB processing and distribution in commerce prohibitions.

Unless EPA grants exemptions, all PCB processing and distribution in commerce will be banned after July 1, 1979 pursuant to section 6(e)(3)(A)(ii) of TSCA. These activities include, but are not necessarily limited to: the processing and distribution in commerce of dielectric fluid for PCB Transformers, PCB-Contaminated Transformers, PCB Railroad Transformers, and PCB Electromagnets; the distribution in commerce of PCB Articles (such as small PCB Capacitors); the processing (*i.e.*, building) and distribution in commerce of PCB Equipment (including the manufacture of fluorescent light ballasts, television sets, air conditioners and microwave ovens and the sale of such PCB Equipment); the processing and distribution in commerce of PCB-contaminated hydraulic fluid; the processing and distribution in commerce of PCBs for servicing mining equipment; the processing and distribution in commerce of chemical substances and mixtures that contain 50 ppm or greater PCB as impurities or contaminants (including diarylide and phthalocyanine pigments, some aluminum chloride, and some phenylchlorosilanes).

In contrast to the Interim Procedural Rules for Exemptions from the PCB Manufacturing Prohibition, the procedural rules published today for exemptions from the processing and distribution in commerce prohibitions provide for class petitions in certain limited circumstances. Allowance of some class petitions is an administrative necessity. EPA estimates that there are thousands of potential petitoners for exemptions from the prohibitions on PCB processing and distribution in commerce. The great majority of these petitions are expected to be concentrated in the areas of distribution of PCB Equipment and distribution of PCB-contaminated substances and mixtures. For example, virtually every retail appliance store, appliance repair service, and wholesale distributor of electrical equipment could need an exemption. Thus, allowing use of class petitions for such persons is a matter of practical reality.

In addition to the sheer number of possible petitioners in a given potential class, EPA evaluated the seriousness of potential risk of injury to health and the environment that could result from permitting a PCB activity to continue if it were granted an exemption. Those persons not allowed to submit class petitions are generally those whose activities involve significant quantities and/or highly concentrated PCB fluids processed or distributed in a non-totally enclosed manner. As a result, the potential risk associated with these activities is relatively high. In such cases it is more important that EPA evaluate petitions individually.

Petitions concerning the manufacture (*i.e.*, processing) of PCB Equipment involving incorporation of PCB Articles into equipment must be submitted on an individual basis. Although this activity in itself may present a low potential risk, the activity results in the wide dissemination of small PCB Capacitors. The disposal of such capacitors is not controlled once the capacitors are processed into PCB Equipment. Since most PCB Equipment manufacturers have converted to non-PCB Capacitors, the number of potential petitioners for exemptions to manufacture PCB Equipment should be small.

These Interim Procedural Rules provide for two types of class petitions and limit the use of each type to certain activities. The two types of class petitions are: (1) a class petition requiring a listing of, and certain information about, each person covered by the petition; and (2) a class petition that does not require a listing of persons covered by the petition.

Once EPA had determined to allow class petitions for certain activities, the same factors previously described (number of potential petitioners and extent of risk) were again evaluated to determine which class petitions would have to identify each petitioner covered by the class petition. In general, those petitions thought likely to represent large numbers of potential petitioners engaged in enclosed or low concentration PCB distribution activities are those allowed to file class petitions without listing each individual petitioner.

Class petitions are not required for persons engaged in those activities permitted to submit class petitions. An individual involved in one of these activities has the choice of either submitting an individual petition or joining with others to submit a class petition. For class petitions, EPA will accept petitions prepared by one company (to which other companies may provide the required information), by a trade association on behalf of its members (as well as others), or by any other person on behalf of a group of persons requiring exemptions.

Persons who have already submitted petitions for exemptions to manufacture or import PCB Equipment pursuant to the Interim Procedural Rules of November 1, 1978 (43 FR 50905) need not submit new petitions, but must advise EPA if they still wish the Agency to act on their pending petitions. If they wish, such petitioners may submit additional information concerning their petitions. Similarly, EPA may request additional information concerning such petitions by letter to the petitioners.

All petitions for exemptions from the 1979 processing and distribution in commerce bans must be received by EPA by July 1, 1979. This deadline is being imposed to permit consolidation of all rulemaking on these petitions and to expedite the rulemaking to the greatest extent possible. The deadline is also the date on which the processing and distribution in commerce prohibitions of section 6(e)(3) of TSCA become effective. EPA estimates that a Notice of Proposed Rulemaking concerning exemptions from the processing and distribution in commerce bans will be published in September 1979, that the public hearing, if requested, will be held in October 1979, and that the Final Rule concerning exemptions will be published in January 1980. Any person who petitions EPA by July 1, 1979 to continue processing or distribution in commerce after July 1, 1979 may continue his activity until EPA rules on his petition. Persons who do not so petition EPA will be subject to the July 1, 1979 ban on all processing and distribution in commerce of PCBs and PCB Items.

In determining whether to grant a petition for exemption to the PCB ban, EPA will apply the standards enunciated in section 6(e)(3)(B) of TSCA. Section 6(e)(3)(B) reads in pertinent part as follows:

> * * * the Administrator may grant by rule such an exemption if the Administrator finds that—
>
> (i) an unreasonable risk of injury to health or environment would not result, and
>
> (ii) good faith efforts have been made to develop a chemical substance which does not present an unreasonable risk of injury to health or the environment and which may be substituted for such polychlorinated biphenyl.

Although EPA is not issuing a form for petitions, petitions must include the information described in § 750.31(d) of the Interim Procedural Rules.

Due to the need to grant or deny petitions on an expedited basis, and pursuant to the delegation of authority by the Administrator in the Preamble to the Final PCB Ban Rule, authority has been delegated to the Assistant Administrator for Toxic Substances to grant or deny petitions under section 6(e)(3)(B) of TSCA submitted pursuant to these interim procedures. The Assistant Administrator will rule on petitions subsequent to opportunity for an informal hearing.

The Interim Procedural Rules applicable to section 6(e) exemption proceedings are adapted from the TSCA section 6 procedural rules (40 CFR Part 750, 42 FR 61259, December 2, 1977, now titled Subpart A—General Procedural Rules).

EPA is aware that many participants at the informal hearings on the proposed PCB Ban and Marking and Disposal Rules presented information directly applicable to a PCB exemption rulemaking. To expedite Agency action on exemption petitions, participants in the PCB exemption informal hearing are permitted and encouraged to designate testimony from prior EPA informal rulemaking hearings on PCBs under TSCA. The exemption hearing panel is specifically authorized by the Interim Procedural Rules to reject repetitive testimony submittted earlier to EPA at a TSCA PCB informal hearing.

These rules are issued under authority of section 6(e) of the Toxic Substances Control Act, 15 U.S.C. 2605(e).

Dated: May 11, 1979.

Marilyn C. Bracken,

Acting Assistant Administrator for Toxic Substances.

Title 40 of the Code of Federal Regulations is amended by adding two Subpart headings, Subpart A—General Procedural Rules for §§ 750.1–750.9 and Subpart B—Manufacturing Exemption Procedural Rules for §§ 750.10–750.21, to the Table of Contents and a new Subpart C as set forth below:

Subpart A—Procedures for Rulemaking under Section 6 of the Toxic Substances Control Act. [§§ 750.1–750.9—Added at 42 FR 61259, December 2, 1977].

Subpart B—Interim Procedural Rules for Manufacturing Exemptions. [§§ 750.10–750.21—Added at 43 FR 50905, November 1, 1978].

Subpart C—Interim Procedural Rules for Processing and Distribution in Commerce Exemptions

Sec.

750.30 Applicability.
750.31 Filing of petitions for exemption.
750.32 Consolidation of rulemaking.
750.33 Notice of proposed rulemaking.
750.34 Record.
750.35 Public comments.
750.36 Confidentiality.
750.37 Subpoenas.
750.38 Participation in informal hearing.
750.39 Conduct of informal hearing.
750.40 Cross-examination.
750.41 Final rule.

Authority: Section 6(e), Toxic Substances Control Act, 15 U.S.C. 2605(e).

Subpart C—Processing and Distribution in Commerce Exemption Procedural Rules

§ 750.30 Applicability.

Sections 750.30–750.41 apply to all rulemakings under authority of section 6(e)(3)(B) of the Toxic Substances Control Act (TSCA), 15 U.S.C. 2605(e)(3)(B) with respect to petitions for PCB processing and distribution in commerce exemptions filed pursuant to § 750.31(a) of this Part.

§ 750.31 Filing of petitions for exemption.

(a) *Who May File.* Any person seeking an exemption from the PCB processing and distribution in commerce prohibitions imposed by section 6(e)(3)(A)(ii) of TSCA may file a petition for exemption. Petitions must be submitted on an individual basis for each processor, distributor, seller or individual affected by the 1979 processing and distribution in commerce prohibitions, except as described in subparagraphs (1) through (9) below.

(1) *Processing and Distribution in Commerce of PCB-Contaminated Transformer Dielectric Fluid.* Persons who process or distribute in commerce dielectric fluid containing 50 ppm or greater PCB (but less than 500 ppm PCB) for use in PCB-Contaminated Transformers may submit a single consolidated petition on behalf of any number of petitioners. The name and address of each petitioner must be stated in the petition.

(2) *Contaminated Substances and Mixtures—Processing.* Persons who process the same chemical substance or the same mixture containing 50 ppm or greater PCB as an impurity or contaminant may submit a consolidated petition if the chemical substance or mixture is processed for the same use by each person represented by the petition. For example, persons who process a PCB-contaminated pigment into printing inks may combine their petitions into one petition. The name and address of each petitioner must be stated in the petition.

(3) *Contaminated Substances and Mixtures—Distribution in Commerce.* Persons who distribute in commerce the same chemical substance or the same mixture containing 50 ppm or greater PCB as an impurity or contaminant may submit a consolidated petition if the chemical substance or mixture is distributed in commerce for a common use. Such a petition is not required to name each person who distributes in commerce the chemical substance or mixture.

(4) *PCB Capacitor Distribution for Purposes of Repair.* Persons who distribute in commerce PCB capacitors for servicing (repair) of PCB Equipment may submit a single consolidated petition on behalf of any number of petitioners engaged in such distribution in commerce for purposes of repair. The name of each petitioner need not be stated in the petition.

(5) *Small Quantities for Research and Development.* Persons who process or distribute in commerce small quantities of PCBs for research and development may submit a single consolidated petition. The name and address of each petitioner must be stated in the petition.

(6) *Microscopy.* Persons who process or distribute in commerce PCBs for use as a mounting medium in microscopy may submit a single consolidated petition on behalf of any number of petitioners. The name and address of each petitioner must be stated in the petition.

(7) *Processing of PCB Articles into PCB Equipment.* A person who processes (incorporates) PCB Articles (such as small PCB Capacitors) into PCB Equipment may submit a petition on behalf of himself and all persons who further process or distribute in commerce PCB Equipment built by the petitioner. For example, a builder of motors who places small PCB Capacitors in the motors may submit a petition on behalf of all persons who process or incorporate motors built by the petitioner into other pieces of PCB Equipment and all those who sell the equipment. Such a petition is not required to identify the persons who distribute in commerce or further process the PCB Equipment. A separate petition must be filed, however, by each processor of PCB Articles into PCB Equipment.

(8) *Processing of PCB Equipment into Other PCB Equipment.* A person who processes (incorporates) PCB Equipment into other PCB Equipment may submit a petition on behalf of himself and all persons who further process or distribute in commerce PCB Equipment built by the petitioner. Such a petition is not required to identify the persons who distribute in commerce or further process the PCB Equipment. If a petition has been filed under subparagraph (a)(7) by the builder of the original PCB Equipment, no other petition is required.

(9) *Distribution of PCB Equipment.* Distributors in commerce of PCB Equipment may submit a consolidated petition on behalf of persons who distribute in commerce PCB Equipment of one type (such as air conditioners). The petition is not required to name the persons who distribute in commerce the affected PCB Equipment.

(b) *Petition Filing Date.* All petitions for exemptions from the 1979 processing and distribution in commerce prohibitions under section 6(e)(3)(A)(ii) must be received by the Hearing Clerk by July 2, 1979.

(c) *Where to File.* All petitions must be submitted to the following location: Document Control Officer (TS–793), Office of Toxic Substances, U.S. Environmental Protection Agency, 401 M Street, SW., Washington, DC 20460, Attn.: Docket Number OTS/066002 (PCB/PDE).

(d) *Content of Petition.* Each petition must contain the following:

(1) Name, address and telephone number of petitioner. See also subparagraphs (a)(1)–(9) for additional identification requirements applicable to certain consolidated petitions.

(2) Description of PCB processing or distribution in commerce exemption requested, including a description of the chemical substances, mixtures or items to be processed or distributed in commerce and, if processing is involved, the nature of the processing.

(3) For processing petitions, location(s) of sites requiring exemption.

(4) Length of time requested for exemption (maximum length of exemption is one year).

(5) Estimated amount of PCBs (by pound and/or volume) to be processed, distributed in commerce, or used during requested exemption period and the manner of release of PCBs into the environment associated with such processing, distribution in commerce, or use. Where the PCB concentration is less than 500 ppm, both the total liquid volume and the total PCB volume must be provided.

(6) The basis for the petitioner's contention that under section 6(e)(3)(B)(i) of TSCA "an unreasonable risk of injury to health or environment would not result" from the granting of the petition for exemption.

(7) The basis for the petitioner's contention that under section 6(e)(3)(B)(ii) "good faith efforts have been made to develop a chemical substance which does not present an unreasonable risk of injury to health or the environment and which may be substituted for" the PCB.

(8) Quantification of the reasonably ascertainable economic consequences of denying the petition for exemption and an explanation of the manner of computation.

(9) In addition to the information in subparagraphs (1) through (8), certain petitions must contain additional information as follows:

(i) Persons who process or distribute in commerce dielectric fluids containing 50 ppm or greater PCB for use in PCB Transformers, railroad transformers, or PCB electromagnets must also state the expected number of PCB Transformers, railroad transformers, or PCB electromagnets to be serviced under the exemption. In addition, a person must identify all the facilities which he owns or operates where he services PCB transformers, railroad transformers, or PCB electromagnets.

(ii) Persons filing petitons under subparagraph (a)(1) (Processing and Distribution in Commerce of PCB-Contaminated Transformer Dielectric Fluid) must also provide the expected number of PCB-Contaminated Transformers to be serviced under the requested exemption and the expected method of disposal of waste dielectric fluid. In addition, a person must identify all the facilities which he owns or operates where he services PCB-Contaminated Transformers. This information, as well as the information required by subparagraphs (d)(1), (d)(3) and (d)(5), must be provided for each person represented by the petition. All other information may be provided on a group basis.

(iii) Persons filing petitions under subparagraphs (a)(2) (Contaminated Substances and Mixtures-Processing) and (a)(3) (Contaminated Substances and Mixtures-Distribution in Commerce) must also provide a justification for the class grouping selected and a description of the uses and the human and environmental exposure associated with each use of the PCB-contaminated chemical substance or mixture for which an exemption is sought. Information may be provided on a group basis, except that the information required by subparagraphs (d)(1), (d)(3) and (d)(5), must be provided for each person represented by a petition under subparagraph (a)(2).

(iv) Persons filing petitions under subparagraph (a)(4) (PCB Capacitor Distribution for Purposes of Repair) must also provide an estimate of the expected total number of PCB Capacitors to be distributed in commerce under the requested exemption. All information may be provided on a group basis.

(v) Persons filing petitions under subparagraph (a)(7) and (a)(8) (Processing of PCB Articles into PCB Equipment and Processing of PCB Equipment into Other PCB Equipment) must provide a description of each type of PCB Equipment (including the amount of PCBs by poundage and/or volume in the PCB Equipment) to be processed and/or distributed in commerce under the exemption, the number of each type of equipment expected to be processed and/or distributed in commerce, and the approximate number of distributors or further processors covered by the petition. All information may be provided on a group basis. However, in the case of a petition under subparagraph (a)(7), the processor of PCB Articles into PCB Equipment must be identified in the petition. In the case of a petition under subparagraph (a)(8), the processor of PCB Equipment who files the petition must be identified.

(vi) Persons filing petitions under subparagraph (a)(9) (Distribution of PCB Equipment) must provide a description of each type of PCB Equipment (including the amount of PCBs by poundage and/or volume in the PCB Equipment) to be distributed in commerce under the exemption, the number of each type of equipment to be distributed in commerce, and the approximate number of distributors covered by the petition. All information may be provided on a group basis.

(vii) Persons filing petitions under subparagraphs (a)(5) and (a)(6) must provide the information required by subparagraphs (d)(1) through (d)(8) for each petitioner named in the petition.

(e) EPA reserves the right to request further information as to each petition where necessary to determine whether the petition meets the statutory tests of section 6(e)(3)(B) of TSCA prior to or after publication of the notice of proposed rulemaking required by § 750.33 of these rules.

§ 750.32 Consolidation of rulemaking.

All petitions received pursuant to § 750.31(a) will be consolidated into one rulemaking with one informal hearing held on all petitions.

§ 750.33 Notice of proposed rulemaking.

Rulemaking for PCB processing and distribution in commerce exemptions filed pursuant to § 750.31(a) will begin with the publication of a Notice of Proposed Rulemaking in the **Federal Register**. Each notice will contain:

(a) A summary of the information required in §750.31(d);

(b) A statement of the time and place at which the informal hearing required by section 6(c)(2)(C) of TSCA shall begin, or, to the extent these are not specified, a statement that they will be specified later in a separate **Federal Register** notice provided that **Federal Register** notice of the date and city at which any informal hearing shall begin will be given at least 30 days in advance;

(c) A statement identifying the place at which the official record of the rulemaking is located, the hours during which it will be open for public inspection, the documents contained in it as of the date the Notice of Proposed Rulemaking was issued, and a statement of the approximate times at which additional materials such as public comments, hearing transcripts, and Agency studies in progress will be added to the record. If any material other than public comments or material generated by a hearing is added to the record after publication of the notice required by this action, and notice of its future addition was not given at the time of that initial publication, a separate **Federal Register** notice announcing its addition to the record and inviting comment will be published;

(d) The due date for public comments, which will be (1) 30 days after publication of the notice of proposed rulemaking for main comments and (2) one week after the informal hearing for reply comments;

(e) The name, address, and office telephone number of the Record Clerk and the Hearing Clerk for the rulemaking in question; and

(f) A nonbinding target date for issuing the final rule.

§ 750.34 Rulemaking record.

(a) No later than the date of proposal of a rule subject to this Subpart, a rulemaking record for that rule will be established. It will consist of a separate identified filing space containing:

(1) All documents required by § 750.31(d);

(2) All public comments timely received;

(3) All public hearing transcripts;

(4) All material received during an informal hearing and accepted for the record of that hearing; and

(5) Any other information that the Assistant Administrator for Toxic Substances considers to be relevant to such rule and that the Assistant Administrator identified, on or before the date of the promulgation of the rule, in a notice published in the **Federal Register**.

(b) All material in the record will be appropriately indexed. Each record will be available for public inspection during normal EPA business hours. Appropriate arrangements allowing members of the public to copy record materials that do not risk the permanent loss of such materials will be made. All material required to be included in the record will be added to the record as soon as feasible after its receipt by EPA.

(c) The Record Clerk for each rulemaking will be responsible for EPA compliance with the requirements of paragraph (a) of this section.

§ 750.35 Public comments.

(a) Main comments must be postmarked or received no later than the time specified in the Notice of Proposed Rulemaking and must contain all comments on and criticisms of that Notice by the commenting person, based on information which is or reasonably could have been available to that person at the time.

(b) Reply comments must be postmarked or received no later than one week after the close of all informal hearings on the proposed rule and must be restricted to comments on:

(1) Other comments;

(2) Material in the hearing record; and

(3) Material which was not and could not reasonably have been available to the commenting party a sufficient time before main comments were due.

(c) Extensions of the time for filing comments may be granted in writing by the Hearing Chairman. Application for an extension must be made in writing. Comments submitted after the comment period and all extensions of it have expired need not be added to the rulemaking record and need not be considered in decisions concerning the rule.

(d) Unless the Notice of Proposed Rulemaking states otherwise, four copies of all comments must be submitted.

§ 750.36 Confidentiality.

EPA encourages the submission of non-confidential information by petitioners and commentors. EPA does not wish to have unnecessary restrictions on access to the rulemaking record. However, if a petitioner or commentor believes that he can only state his position through the use of information claimed to be confidential, he may submit it. Such information must be separately submitted for the rulemaking record and marked "confidential" by the submitter. For the information claimed to be confidential, EPA will list only the date and the name and address of the petitioner or commentor in the public file, noting that the petitioner or commentor has requested confidential treatment. The information claimed to be confidential will be placed in a confidential file. A petitioner must also file a non-confidential petition with a non-confidential summary of the confidential information to be placed in the public file. Similarly, a commentor must supply a non-confidential summary of the information claimed to be confidential to be placed in the public file. Any information not marked as confidential will be placed in the public file. Information marked confidential will be treated in accordance with the procedures in Part 2, Subpart B of this Title.

§ 750.37 Subpoenas.

(a) Where necessary, subpoenas requiring the production of documentary material, the attendance of persons at the hearing, or responses to written questions may be issued. Subpoenas may be issued either upon request as provided in paragraph (b) or by EPA on its own motion.

(b) All subpoena requests must be in writing. Hearing participants may request the issuance of subpoenas as follows:

(1) Subpoenas for the attendance of persons or for the production of documents or responses to questions at the legislative hearing may be requested at any time up to the deadline for filing main comments.

(2) Subpoenas for production of documents or answers to questions after the legislative hearing may be requested at any time between the beginning of the legislative hearing and the deadline for submitting reply comments.

(c) EPA will rule on all subpoena requests filed under paragraph (b)(1) no later than the beginning of the informal hearing. Such requests may be granted, denied, or deferred. EPA will rule on all subpoena requests filed under paragraph (b)(2) and all deferred subpoena requests filed under paragraph (b)(1) no later than the promulgation of the final rule. Such requests will be either granted or denied.

§ 750.38 Participation in informal hearing.

(a) Each person or organization desiring to participate in the informal hearing required by section 6(c)(2)(C) of TSCA must file a written request to participate with the Hearing Clerk. This request must be received no later than seven days prior to the scheduled start of the hearing. The hearing will begin seven days after the close of the thirty day comment period or as soon thereafter as practicable. The request must include:

(1) A brief statement of the interest of the person or organization in the proceeding;

(2) A brief outline of the points to be addressed;

(3) An estimate of the time required; and

(4) If the request comes from an organization, a nonbinding list of the persons to take part in the presentation. Organizations are requested to bring with them, to the extent possible, employees with individual expertise in and responsibility for each of the areas to be addressed. No organization not filing main comments in the rulemaking will be allowed to participate at the hearing, unless a waiver of this requirement is granted in writing by the Hearing Chairman or the organization is appearing at the request of EPA or under subpoena.

(b) No later than three days prior to the start of the hearing, the Hearing Clerk will make a hearing schedule publicly available and mail or deliver it to each of the persons who requested to appear at the hearing. This schedule will be subject to change during the course of the hearing at the discretion of those presiding over it.

(c) Opening statements should be brief, and restricted either to points that could not have been made in main comments or to emphasizing points which are made in main comments, but which the participant believes can be more forcefully urged in the hearing context.

§ 750.39 Conduct of informal hearing.

(a) A panel of EPA employees shall preside at each hearing conducted under section 6(c)(2)(C) of TSCA. In appropriate cases, other Executive Branch employees may also sit with and assist the panel. The membership of the panel may change as different topics arise during the hearing. In general, the panel membership will consist of EPA employees with special responsibility for the final rule or special expertise in the topics under discussion. One member of the panel will be named to chair the proceedings and will attend throughout the hearing, unless unavoidably prevented by sickness or similar personal circumstances.

(b) The panel may question any individual or group participating in the hearing on any subject relating to the rulemaking. Cross-examination by others will normally not be permitted at this stage. It may be granted in compelling circumstances at the sole discretion of the hearing panel. However, persons in the hearing audience may submit questions in writing for the hearing panel to ask the participants, and the hearing panel may, at their discretion, ask these questions.

(c) Participants in the hearing may submit additional material for the hearing record and shall submit such additional material as the hearing panel may request. All such submissions will become part of the record of the hearing. A verbatim transcript of the hearing shall be made. Participants will be allowed to designate testimony from prior EPA informal rulemaking hearings concerning PCBs under TSCA. The hearing panel may reject repetitive testimony previously presented at such hearings.

§ 750.40 Cross-examination.

(a) After the close of the informal hearing conducted under § 750.39, any participant in that hearing may submit a written request for cross-examination. The request must be received by EPA within one week after a full transcript of the informal hearing becomes available and must specify:

(1) The disputed issue(s) of material fact as to which cross-examination is requested. This must include an explanation of why the questions at issue are "factual", rather than of an analytical or policy nature, the extent to which they are in "dispute" in the light of the record made thus far, and the extent to which and why they can reasonably be considered "material" to the decision on the final rule; and

(2) The person(s) the participant desires to cross-examine, and an estimate of the time necessary. This must include a statement as to how the cross-examination requested can be expected to result in "full and true disclosure" resolving the issue of material fact involved.

(b) Within one week after receipt of all requests for cross-examination under subparagraph (a), the hearing panel will rule on them. The ruling will be served by the Hearing Clerk on all participants who have requested cross-examination and will be inserted in the record. Written notice of the ruling will be given to all persons requesting cross-examination and all persons to be cross-examined. The ruling will specify:

(1) The issues as to which cross-examination is granted;

(2) The persons to be cross-examined on each issue;

(3) The persons to be allowed to conduct cross-examination; and

(4) Time limits for the examination of each witness by each cross-examiner.

(c) In issuing this ruling, the panel may determine that one or more participants who have requested cross-examination have the same or similar interests and should be required to choose a single representative for purposes of cross-examination by that single representative without identifying the representative further. Subpoenas for witnesses may be issued where necessary.

(d) Within one week after the insertion into the record of the ruling under subparagraph (b), the hearing at which the cross-examination will be conducted will begin. One or more members of the original panel will preside for EPA. The panel will have authority to conduct cross-examination on behalf of any participant, although as a general rule this right will not be exercised. The panel will also have authority to modify the governing ruling in any respect and to make new rulings on group representation under section 6(c)(3)(C) of TSCA. A verbatim transcript of the hearing will be made.

(e)(1) No later than the time set for requesting cross-examination, a hearing participant may request that other alternative methods of clarifying the record (such as informal conferences or the submittal of additional information) be used. Such requests may be submitted either in lieu of cross-examination requests, or in conjunction with them.

(2) The panel in passing on a cross-examination request may, as a precondition to ruling on its merits, require that alternative means of clarifying the record be used whether or not that has been requested under subparagraph (e)(1). In such a case, the results of the use of such alternative means will be made available to the person requesting cross-examination for a one-week comment period, and the panel will make a final ruling on cross-examination within one week thereafter.

(f) Waivers or extensions of any deadline in this section applicable to persons other than EPA may be granted on the record of the hearing by the person chairing it or in writing by the Hearing Chairman.

§ 750.41 Final rule.

(a) As soon as feasible after the deadline for submittal of reply comments, EPA will issue a final rule. EPA will also publish at that time:

(1) A list of all material added to the record (other than public comments and material from the hearing record) which has not previously been listed in a **Federal Register** document, and

(2) The effective date of the rule.

(b) Pursuant to the delegation of authority made in the Preamble to the Final Regulation for the PCB Manufacturing, Processing, Distribution in Commerce and Use Prohibitions, the Assistant Administrator for Toxic Substances will grant or deny petitions under section 6(e)(3)(B) of TSCA submitted pursuant to § 750.31. The Assistant Administrator will act on such petitions subsequent to opportunity for an informal hearing pursuant to this rule.

(c) In determining whether to grant an exemption to the PCB ban, EPA will apply the two standards enunciated in section 6(e)(3)(B) of TSCA.

[FR Doc. 79-16900 Filed 5-30-79; 8:45 am]

BILLING CODE 6560-01-M

ENVIRONMENTAL PROTECTION AGENCY

[40 CFR Part 761]

[FRL 1227-7; OTS-066001]

Polychlorinated Biphenyls (PCBs); Proposed Rulemaking for PCB Manufacturing Exemptions

AGENCY: Environmental Protection Agency.

ACTION: Proposed PCB exemption rule; notice of informal hearing.

SUMMARY: This notice lists the petitions received by EPA for exemption from the prohibition on PCB manufacturing and importation pursuant to section 6(e)(3) of the Toxic Substances Control Act (TSCA), 15 U.S.C. 2605(e)(3). The notice also indicates, the most cases, which petitions for exemption EPA proposes to grant and which petitions the Agency proposes to deny.

DATES: Written comments, preferably in triplicate, must be received by the Hearing Clerk by July 2, 1979. Hearing Date and Time: July 9, 1979 at 10:00 a.m. in Washington, D.C. Requests to participate in the hearing must be received by the Hearing Clerk by July 2, 1979.

ADDRESSES: Send comments and requests to participate in the hearing to: Ms. Linda Thomson, Hearing Clerk, Office of Toxic Substances (TS-794), U.S. Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20460, Attention: Docket Number OTS/066001 (PCB/ME). The hearing will be held in Washington, D.C. The exact location of the hearing will be made available by calling the toll-free number 800-424-9065.

FOR FURTHER INFORMATION CONTACT: John B. Ritch, Director, Office of Industry Assistance (TS-799), Office of Toxic Substances, Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20460, telephone (800)-424-9065, or in Washington, D.C. call 554-1404.

SUPPLEMENTARY INFORMATION: Section 6(e)(3)(A) of TSCA (Pub. L. 94-469, 90 Stat. 2003, 15 U.S.C. 2601 *et seq.)* prohibits all manufacture (including importation) of PCBs as of January 1, 1979. EPA's regulation entitled PCB Manufacturing, Processing, Distribution in Commerce, and Use Prohibition Rule (PCB Prohibition Rule) which implements the prohibitions of section 6(e)(3) of TSCA, appears elsewhere in today's **Federal Register**. Section 6(e)(3)(B) of TSCA allows affected persons to petition EPA for exemptions from the section 6(e)(3)(A) PCB prohibitions. On November 1, 1978, EPA published Interim Procedural Rules (43 FR 50905) for the filing and processing of petitions for exemptions from the PCB manufacturing prohibition of section 6(e)(3) of TSCA. More than seventy petitions for exemption have been received. These petitions have been consolidated into one rulemaking in accordance with § 750.12 of the Interim Procedural Rules (43 FR at 50906).

On January 2, 1979, the Agency announced (44 FR 108) that persons who had filed petitions for exemptions from the PCB manufacturing ban under section 6(e)(3)(B) of TSCA could continue the manufacturing or importation activity for which the exemption is sought until EPA has acted on the applicable petition.

The Interim Procedural Rules for manufacturing exemptions (43 FR 50905) will be applicable to this rulemaking. The official record of rulemaking is located in Room 447, East Tower, Environmental Protection Agency, 401 M Street, S.W., Washington, D.C. 20460, telephone (202)-755-6956. It will be available for viewing and copying from 9:00 a.m. to 4:00 p.m., Monday through Friday, excluding holidays. Hearing transcripts, hearing materials and submissions received will be added to the record as they become available.

To facilitate informed comment, EPA is indicating its proposed action on most exemption petitions. For EPA to grant a requested exemption, the Agency must make the findings required by section 6(e)(B)(3) of TSCA. That section reads as follows:

> * * * the Administrator may grant by rule such an exemption if the Administrator finds that—
>
> (i) An unreasonable risk of injury to health or environment would not result, and
>
> (ii) Good faith efforts have been made to develop a chemical substance which does not present an unreasonable risk of injury to health or the environment and which may be substituted for such polychlorinated biphenyl.

EPA wishes to advise commentors that for each exemption petition the Agency may request by letter additional information from the petitioner concerning his petition. This information would be supplementary to information requested in this Notice. The Agency will make such requests if it determines that it requires the information in order to adequately assess the petition. Accordingly, persons may wish to file reply comments under § 750.15 of the Interim Procedural Rules (43 FR 50906) on any additional material filed by petitioners in response to information requests from EPA.

Section 750.11(b) of the Interim Procedural Rules established a filing date of December 1, 1978 for all petitions for exemption from the TSCA section 6(e)(3) PCB manufacturing (and important) prohibition. Subsequent to the filing date, additional petitions have been received by the Agency. Due to the shortness of the original filing period of thirty days, EPA has accepted all late petitions. The Agency will decide on a case-by-case whether petitions for exemptions for PCB manufacturing and importation activities filed subsequent to the date of this Notice should also be accepted. If a PCB manufacturer or importer subject to the final PCB regulation (1) now wishes to file a petition for exemption and (2) did not earlier file a petition because he had good cause to believe his PCB activity was not subject to the proposed regulation (43 FR 24802, June 7, 1978), he should indicate the basis for his prior failure to file a petition and should request EPA to accept his late petition. No late petition will be accepted unless good cause can be shown for the failure to file on time. Whether or not late petitions are accepted will be announced at the informal hearing for this rulemaking. A supplemental notice of proposed rulemaking probably will not be issued as to such petitions.

In the preamble to the final PCB Prohibition Rule (see preamble section VI.C.1.), EPA states: ". . . the prohibition applies to the manufacture of any substance or mixture that contains PCB at 50 ppm or greater, including PCB that is an intermediate or 'impurity' or 'byproduct'. . . . While the production of PCBs under such circumstances may not be intentional and may have no independent commercial value, section 6(e) of TSCA applies to *any* production of PCBs and, therefore, covers such activities." EPA is aware that although the proposed rule included such PCBs in its coverage, some manufacturers may not have interpreted the proposed rule to include such PCBs and, therefore, may not have submitted a petition for an exemption from the manufacturing prohibition. As discussed above, EPA will accept petitions from such persons during the comment period for this rule, if the required showing of good faith in not filing earlier is made.

Several persons requested that petitions be accepted on a class basis. They argued that PCB equipment manufacturers should be able to petition for exemptions on behalf of those customers who are also PCB equipment manufacturers or distributors as defined in the proposed regulation.* In view of the change which has been made concerning restrictions on the manufacture of PCB equipment in the final PCB Prohibition Rule,** EPA will not accept exemption petitions on a class basis in this rulemaking. However, the Agency has addressed the question of class petitions in the Interim Procedural Rules which establish procedures for filing and processing exemption petitions from the July 1, 1979 PCB processing and distribution in commerce prohibitions. These Interim Procedural Rules are found elsewhere in today's **Federal Register.**

It is the intent of EPA to grant or deny the petitions for exemption from the prohibition of the manufacture (including importation) of PCBs subject to this rulemaking prior to August 1, 1979.

Below are listed the exemption petitions that EPA has received. These exemptions have been categorized according to the nature of the petition, and the categories are indicated by a numbered key. The Agency's proposed action on the petitions follows the listing.

Petitioner and Basis for Petition

Abolite Lighting, Inc., P.O. Box 237, West Lafayette, OH 43845.
Advance Transformer Co., 2950 North Western Ave., Chicago, IL 60618.[2]
Aluminum Company of America, 1501 Alcoa Building, Pittsburgh, PA 15219.[3]
American Hoechst Corp., Route 202–206 North, Somerville, NJ 08876.[4]
Binney and Smith, Inc., 1100 Church Lane, P.O. Box 431, Easton, PA 18042.[4]
Borden, Inc., Borden Chemical Division, 630 Glendale-Milford Rd., Cincinnati, OH 45215.[4]
Chemetron Pigments, Division of Chemetron Corp., 491 Columbia Ave., Holland, MI 49423.[4]
Chemical Waste Management Limited, 211 King Street, P.O. Box 1288, St. Catherines, Ontario, Canada L2R7A7.[5]
Ching Mei U.S.A. Ltd., 350 Fifth Ave., Rm. 1825, New York, NY 10001.[4]
Cincinnati Milacron Inc., 4701 Marburg Ave., Cincinnati, OH 45209.[6]
Colt Industries, Inc., Fairbanks Morse Pump Division, 3601 Fairbanks Ave., Kansas City, KS 66110.[7]
Columbia Lighting Inc., Terminal Annex, Box 2787, Spokane, WA.[1]
Control Data Corporation, Autocon Industries Inc., Subsidiary of Control Data Corp., 2300 Berkshire Lane, Minneapolis, MN 55441.[7]
Copeland Corp., Sidney, OH 45365.[8]
Crouse-Hinds Co., P.O. Box 4999, Wolf and Seventh North St., Syracuse, NY 13221.[1]
Dainichiseika Color & Chemicals, America, Inc., 20 Hook Mountain Rd., Pine Brook, NJ 07058.[4]
Dainippon Ink & Chemicals America, Inc., 200 Park Ave., New York, NY 10017.[4]
Day-Brite Lighting, 1015 South Green St., P.O. Drawer 1687, Tupelo, MS 38801.[1]
Dow Corning Corp., Midland, MI 48640.[9]
Dunham-Bush, Inc., 101 Burgess Road, Harrisonburg, VA 22801.[10]
Emerson Quiet Kool Corp., 400 Woodbine Ave., Woodbridge, NJ 07095.[8]
Emerson Electric Co., Industrial Control Division, 3300 S. Standard St., P.O. Box 1679, Santa Ana, CA 92702.[10]
Emerson Electric Company, Gearmaster Division, 1809 S. Route 31, McHenry, IL 60050.[10]
General Electric Company, 3135 Easton Turnpike, Fairfield, CT 06431.[1] [11] [2] [10]
Globe Illumination Company, 1515 W. 178th St., Gardena, CA 90248.[1]
Guardian Chemical Corp., Eastern Chemical Division, 230 Marcus Blvd., Hauppauge, NY 11787.[12]
Guardian Light Co., 5125 W. Lake St., Chicago, IL 60644.[1]
Halstead Industries, Inc., Halstead and Mitchell/Division, Highway 72 West, Scottsboro, AL 35768.[10]
Harmon Colors Corp., 550 Belmont Ave., Haledon, NJ 07508.[4]
Harvey Hubbell, Inc., (Lighting Division), 2000 Electric Way, Christianburg, VA 24073.[1]
Hercules, Inc., 910 Market St., Wilmington, DE 19889.[4]
Hills-McCanna Co., 400 Maple Ave., Carpentersville, IL 60110.[10]
Hilton-Davis Chemical Co., Division of Sterling Drug Inc., 2235 Langdon Farm Road, Cincinnati, OH 45237.[4]
Honeywel., Inc., 200 Smith St., Waltham, MA 02154.[13]
ICI Americas, Inc., Wilmington, DE 19897.[4]
International Telephone & Telegraph Corp., 260 Cochituate Road, Suite 109, Framington, MA 07101.[1]
Intsel Corp., 825 Third Ave., New York, NY 10022.[14]
Keene Corporation-Lighting Division, Industrial Way, Wilmington, MA 01887.[1]
Keystone Lighting Corp., Inc., U.S. 13 & Beaver Streets, Bristol, PA 19007.[1]
Kramer Trenton Co., Box 620, Trenton, NJ 08605.[10]
Lightolier, Inc., 346 Claremont Ave., Jersey City, NJ 07305.[1]
Litton Industrial Products, Inc., Louis Allis Division, 16555 West Ryerson Road, New Berlin, WI 53151.[15]
Litton Microwave Cooking, Litton Systems, Inc., P.O. Box 9461, Minneapolis, MN 55440.[16]
Litton Systems Inc., Jefferson Electric Division, 840 South 25th Ave., Bellwood, IL 60104.[1]
Marathon Electric Manufacturing Corp., P.O. Box 1407, Wausau, WI 54401.[10]
McGraw-Edison Co., Area Lighting Div., 7601 Durand Ave., Racine, WI 53405.[1]
McGraw-Edison Co., Kitchen Appliance Division, P.O. Box 1111, Chattanooga, TN 37401.[16]
Metalux Corp., P.O. Box 1207, Americus, GA 31709.[1]
The Miller Company, Lighting Division, 99 Center Street, Meridian, CT 06450.[1]
Montedison USA, Inc., 1114 Ave. of the Americas, New York City, NY 10036.[4]
Nagase America Corp., 500 Fifth Ave., New York, NY 10036.[4]
National Services Industries, Lithonia Lighting Div., 1335 Industrial Blvd. NW., Conyers, GA 30207.[1]
National Solid Waste Management Association, 1120 Connecticut Ave.,NW., Washington, DC 20036.[5]
Phillips Petroleum Company, 10 C2 Phillips Bldg., Bartlesville, OK 74004.[17]
Phthalchem Inc., 6675 Beechlands Dr., Cincinnati, OH 45237.[4]
Pope Chemical Corp., 33 Sixth Ave., Paterson, NJ 07524.[4]
Prescolite, 1251 Doolittle Drive, San Leandio, CA 94557.[7]

---

*See the definition of "PCB" in Section 761.2(q) of the proposed PCB Prohibition Rule (43 FR at 24813, June 7, 1978) and the definition of "PCB Equipment" in Section 761.2(v) of the final PCB Disposal and Marking Rule (43 FR at 7157, February 17, 1978).

This change classifies the manufacture of PCB equipment as "processing" subject to prohibition as of July 1, 1979 under Section 6(e)(3)(A)(ii) of TSCA. The proposed regulation classified such activity as "manufacture" subject to prohibition as of January 1, 1979 under Section 6(e)(3)(A)(i). For further discussion, see Section VI.B.1.a. of the preamble to the final PCB Prohibition Rule, which appears elsewhere in today's **Federal Register.

[1] Requests an exemption in order to manufacture either fluorescent or High Intensity Discharge (HID) lighting fixtures with a PCB capacitor or PCB ballast transformer.

[2] Requests an exemption in order to manufacture PCB ballast transformers which can be used by its customers in the manufacture of fluorescent and HID lighting fixtures.

[3] Requests an exemption in order to continue manufacturing aluminum chloride which is contaminated with PCBs.

[4] Requests an exemption to either manufacture or import diarylide yellow or phthalocyanine pigments.

[5] Requests an exemption in order to import into the United States PCB waste material for disposal.

[6] Requests an exemption in order to incorporate PCBs as an additive component in rigid PVC vibration damping devices used in large machine tools.

[7] Requests an exemption in order to use PCB capacitors in the manufacture of electric pumps and water and waste water control systems.

[8] Requests an exemption in order to use PCB capacitors in the manufacture of air conditioners or air conditioner sub-assemblies.

[9] Requests an exemption in order to continue manufacturing an unspecified chemical using a PCB contaminated intermediate.

[10] Requests an exemption in order to manufacture motors using a PCB capacitor or to manufacture another product or system using such a motor.

[11] Requests an exemption in order to continue manufacturing phenylchlorosilanes with unintentional PCB impurities.

[12] Requests an exemption in order to sell a small quantity of PCB.

[13] Requests an exemption in order to import PCB equipment and small PCB capacitors for purposes of repair, replacement and trade-in.

[14] Requests an exemption in order to import a dielectric called Electrophenyl T–60 which is contaminated with PCB.

[15] Requests an exemption in order to use PCB capacitors in the manufacture of power conversion equipment.

[16] Requests an exemption in order to use PCB capacitors in the manufacture of microwave ovens.

[17] Requests an exemption in order to import PCBs for use in research and development of an unspecified chemical intermediate.

Ridgeway Color & Chemical of Wheelabrator-Fry, Inc., 75 Front St., Ridgeway, PA 15853.[4]

Rollins Environmental Services, Inc., One Rollins Plaza, P.O. Box 2349, Wilmington, DE 19899.[5]

Sandoz, Inc., Sandoz Colors and Chemicals Division, 59 Route 10, East Hanover, NJ 07936.[4]

Sim-Kar Lighting Fixture Co., Inc., 601 East Cayuga Street, Philadelphia, PA 19120.[1]

Spero Electric Corp., 18222 Lanken Ave., Cleveland, OH 44119.[1]

Sta-Rite Industries Inc., Suite 3300, 977 East Wisconsin Ave., Milwaukee, WI 53202.[7]

Stauffer Chemical Company, on behalf of SWS Silicones Corp. Subsidiary, Westport, CT 06880.[18]

Steelcase Inc., 1120 36th Street, Grand Rapids, MI 49501.[1]

Sterner Lighting Systems, Inc., 351 Lewis Ave., NW., Winstead, MN 55395.[1]

Sun Chemical Corp., Pigments Division, Research & Operations Center, 4625 East Ave., Cincinnati, OH 45232.[4]

Sumitomo Corporation of America, 345 Park Ave., New York, NY 10022.[4]

Tappan Air Conditioning-Smith Jones, Inc., 206 Woodford Ave., Elyira, OH 44035.[8]

Tivian Chemical Associates, 720 Union Street, Manchester, NH 03104.[18]

Thomas Industries, Inc., Benjamin Division, P.O. Box 180, Sparta, TN 38583.[1]

Toyo Ink America, Inc., 560 Sylvan Ave., Englewood Cliffs, NJ 07632.[4]

Universal Manufacturing Corp., 29 E. 6th Street, Paterson, NJ 70509.[3]

Vivitar Corp., 1630 Stewart Street, Santa Monica, CA 90406.[20]

Weatherking, Inc., P.O. Box 20434, Orlando, FL 32814.[8]

Westinghouse Electric Corp., Lighting Business Unit, P.O. Box 824, Vicksburg, MS 39180.[1] [19]

Whiteway Manufacturing Co., 1736 Dreman Avenue, Cincinnati, OH 45223.[1]

Wide-Lite Corp., P.O. Box 606, Redwood Rd. & IH35, San Marcos, TX 78666.[1]

Wylain, Inc., Mold Cast Lighting Division, I-80 at Maple Avenue, Pine Brook, NJ 07058.[1]

EPA has completed a preliminary analysis of the above-listed petitions for exemption from the PCB Prohibition Rule which was promulgated elsewhere in today's **Federal Register**. The Agency has decided that it will not evaluate at this time any of the 49 requests for exemption from the prohibitions on manufacturing equipment which contains a PCB capacitor. (The requests which fall in this category are those footnoted with numbers 1, 2, 7, 8, 10, 13, 15, 16, 20.) EPA is not processing these requests in the present proceeding because, as previously noted, the Agency defines in the final PCB Prohibition Rule the activity of "manufacturing" equipment utilizing a PCB capacitor as "processing" of PCBs. Processing of PCBs is not subject to section 6(e)(3) until July 1, 1979.

EPA will consider petitions concerning PCB processing activities in a subsequent proceeding. Persons who filed requests for exemptions for this activity will not be required to refile. However, they will be required under Interim Procedural Rules, found elsewhere in today's **Federal Register**, to indicate to EPA in writing if they wish their petitions to be considered as requests for exemption from the July 1, 1979 prohibition on processing or distribution in commerce of PCBs.

Imports of PCB Wastes

Chemical Waste Management, Ltd., the National Solid Waste Management Association, and the Rollins Environmental Services, Inc., petitioned to continue importation of PCB waste material into the U.S. for purposes of disposal. These petitions have been mooted by the PCB Prohibition Rule published elsewhere in today's **Federal Register**. For the reasons explained in the preamble to that regulation, EPA has decided to allow imports and exports of PCB waste for disposal (so long as such disposal is in accordance with Subpart B of the regulation) until May 1, 1980. Accordingly, no petitions for importation of PCB wastes for disposal are required.

Manufacture and Import of Pigments

EPA proposes to grant all of the requests to either manufacture or import diarylide and phthalocyanine pigments containing more than 50 ppm PCB. (These petitions are identified in the above list with footnote number 4). Information submitted with the requests and testimony and written comments received during the rulemaking for the PCB Manufacturing, Processing, Distribution in Commerce and Use Prohibition Rule which EPA promulgated today indicates (1) granting these exemption requests would not result in an unreasonable risk of injury to health or the environment and (2) good faith efforts are being made by the pigment industry to develop alternative processes for manufacturing the diarylide and phthalocyanine pigments without PCB contamination. Most of these pigments have PCB concentrations in the range of several hundred parts per million. These PCBs cannot easily be separated from the pigments because of the structural similarity of the PCBs with the pigments. Once manufactured, the pigments are mixed with other substances to form paints, inks, and a variety of other products.

In deciding whether to permit continued pigment manufacture, EPA has considered the relatively limited human and environmental exposure to PCBs involved and the economic effects associated with prohibiting manufacture of these pigments. The greatest potential for exposure is in the application of the paints and inks using these pigments. These products contain far less than 50 ppm PCB because of the dilution that takes place when the pigment is mixed with the medium it is coloring. As a result, the health and environmental risks are relatively small. At the present time, these particular pigments account for most of the yellow and blue pigments in use and a significant portion of the total pigment market. If the manufacture of these pigments is not permitted until the conversion to alternative processes is complete, there will be a severe impact on the pigment industry as well as its customers in the paint and graphic arts industries.

The potential costs of compliance will be greatly reduced if an exemption is granted while process changes to reduce PCB contamination are made. It is anticipated that such changes can be made over a period of a year or two. The increased health and environmental risk will be relatively small as there will be limited exposure to PCBs as a result of the exemption.

Furthermore, the granting of these exemption requests will be consistent with the authorization for continued use of phthalocyanine and diarylide yellow pigments which is contained in the final PCB Prohibitions Rule.

EPA especially invites comment not only on the merits of granting the above described petitions, but also on the terms and conditions which the Agency should apply to such exemptions if granted.

Import of PCB Equipment

Honeywell Inc.'s request to be permitted to continue importing PCB equipment will not be evaluated in this proceeding but will be evaluated (if requested) in the future rulemaking dealing with exemptions from the prohibition on processing and distribution in commerce of PCBs. The PCB Prohibition Rule which EPA promulgated today treats importation of PCB equipment in the same manner as the domestic assembly of such equipment and, therefore, such activity is not prohibited until July 1, 1979.

---

[18] Requests an exemption in order to continue importing a polysiloxane intermediate which is used in the manufacture of heat curable silicone rubber products and which is contaminated with 600 ppm PCBs. Chemical (polysiloxane intermediate) is described generically because petitioner has claimed confidential treatment for identity of chemical.

[19] Requests an exemption in order to continue unspecified activity which may be subject to either January 1, 1979 or July 1, 1979 prohibitions. See later discussion in this Notice.

[20] Requests an exemption in order to use PCB capacitors in the manufacture of photographic enlargers.

Other Petitions

Guardian Chemical Corporation's request to be permitted to sell small quantities of 4,4'-Dichlorodiphenylsulfane as a laboratory reagent also will not be evaluated now but will be evaluated (if requested) in the processing and distribution in commerce exemption proceeding. Guardian did not indicate that they in any way manufacture PCBs. However, it does appear that the activity which is seeks to continue is the "distribution in commerce" of PCBs.

Similarly, the petition submitted by Cincinnati Milacron which, if granted, would permit the company to continue to use PCBs as an additive component in their manufacture of polyvinyl chloride vibration damping devices will not be considered now but will be considered in the future proceeding, if requested. The reason for delaying the processing of Cincinnati Milacron's petition is that EPA has determined that the company's use of PCBs is "processing" as that term is defined by the PCB Prohibition Rule and is therefore not subject to this proceeding.

Exemption Requests Proposed To Be Denied

EPA proposes to deny Intsel Corporation's request to import Electrophenyl T–60 and Phillips Petroleum Company's request to import significant quantities of PCBs for unspecified research and development purposes. Neither of the requestors have shown that they are making a good faith effort to develop substitutes which do not contain 50 ppm or greater PCBs, nor that the adverse economic or other consequences of EPA's denying the requests outweigh the potential harm to health and the environment of EPA's granting the requests.

Exemption Requests for Which a Determination Is Not Proposed

EPA has not proposed its disposition of the requests received from Alcoa which respect to its manufacture of aluminum chloride and the General Electric Co. with respect to its manufacture of phenylchlorosilanes due to the technical complexity of the activities for which exemptions are sought.

Before making a determination with respect to these exemption petitions, the Agency will seek, by means of written requests to the companies and by this notice, further comments and/or data. Additional information on these petitions is given below.

Alcoa requested a one-year exemption for the manufacture of approximately 132.77 million pounds of aluminum chloride at its facility in Anderson County, Texas. The process would result in the annual production of approximately 9,294 pounds of PCBs, 95% of which is concentrated and disposed of as a PCB mixture. The remaining 5% represents an impurity in the aluminum chloride which Alcoa sells for a variety of uses. Comments and data are requested on the health and environmental risks that would be posed by granting Alcoa's exemption and also on the risks associated with using the aluminum chloride for applications other than smelting aluminum. In particular, EPA is interested in information regarding processes for the production of aluminum chloride which do not produce PCBs. In addition, EPA invites comments on the economic or other adverse impacts that denial of the exemption would have on Alcoa's users of this product.

General Electric seeks an exemption to continue the manufacture of phenylchlorosilanes with unintentional PCB impurities. The manufacturing process results in approximately 50,000 pounds per year of PCBs which are removed and concentrated for disposal in an on-site incineration facility in Waterford, New York. The phenylchlorosilanes are used in the production of a number of high performance silicone products for various industrial, aerospace, and defense applications. Comments and data are requested on the health and environmental risk associated with granting or denying General Electric's exemption petition, on alternative methods of manufacturing phenylchlorosilanes without PCB contamination, and on the impact of denying this petition on the users of this chemical.

EPA has also not proposed its disposition of the petition of Tivian Chemical Associates. EPA is seeking to clarify whether Tivian's activity for which exemption is sought is subject to the January 1, 1979 prohibition on PCB manufacture and importation, or rather to the July 1, 1979 prohibition on PCB processing and distribution in commerce.

In addition, EPA has not proposed its disposition of the petitions of Dow Corning Corporation and Stauffer Chemical Company. EPA currently does not have sufficient information to determine whether exemptions should be proposed for these companies. Dow Corning has not identified the substance which it wishes to manufacture and the amount of PCB contamination in the chemical intermediate. Stauffer has not provided sufficient information concerning the identity of products which may be subject to PCB contamination. EPA will seek, by means of written requests to both companies, to clarify the identity of the products identified in the petitions of the companies, and the nature of the manufacturing processes, which includes determining whether intermediates are contaminated during the manufacturing process.

Section 750.13 of the Interim Procedural Rules does not require EPA to announce its proposed disposition of exemption petitions in a Notice of Proposed Rulemaking. Due to the need to expedite action on the exemption petitions, EPA will not publish a subsequent notice concerning the Alcoa, General Electric, Tivian, Dow Corning and Stauffer petitions.

Dated: May 11, 1979.

Marilyn C. Bracken,

Acting Assistant Administrator for Toxic Substances.

[FR Doc. 79-16801 Filed 5-30-79; 8:45 am]

BILLING CODE 6560-01-M

[40 CFR Part 761]

[FRL 1227-6]

Polychlorinated Biphenyls (PCBs); Amendment to Criteria for Chemical Waste Landfills

AGENCY: Environmental Protection Agency.

ACTION: Proposed amendment to final rule; notice of informal hearing.

SUMMARY: This proposed rule would modify Annex II of Subpart E of the Polychlorinated Biphenyls regulation promulgated elsewhere in today's **Federal Register** under the authority of section 6(e) of the Toxic Substances Control Act. The proposed rule would amend the criteria for chemical waste landfills by reducing the required distance between the bottom of the chemical waste landfill liner system and the historical high water table from fifty feet to five feet.

DATES: Written comments, preferably in triplicate, must be received prior to the close of business July 16, 1979. Informal hearing date and time (if a hearing is requested): August 6, 1979, at 10:00 a.m. in Washington, DC. Requests to hold a hearing and to participate in the hearing must be received prior to the close of business on July 16, 1979. See Supplementary Information below.

ADDRESSES: Send comments to: Document Control Officer (TS-793), Office of Toxic Substances, U.S. Environmental Protection Agency, 401 M Street, SW, Washington, DC 20406, Attn: Docket Number OTS/066000(PCB/RR). The informal hearing (if a hearing is requested) will be held in Washington, DC. The exact location of the hearing will be made available by calling the toll-free number 800-424-9065. Address requests to participate to Ms. Linda Thomson, Hearing Clerk, Office of Toxic Substances (TS-794), U.S. Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460, Attn: Docket Number OTS/066000(PCB/RR) The telephone number for Ms. Thomson is (202)-755-1188.

FOR FURTHER INFORMATION CONTACT: John B. Ritch, Jr., Director, Office of Industry Assistance, Office of Toxic Substances (TS-799), Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460. Call the toll free number (800)-424-9065, (in Washington, DC, 554-1404).

SUPPLEMENTARY INFORMATION: The Environmental Protection Agency proposes this rule pursuant to the authority of section 6(e) of the Toxic Substances Control Act (Pub. L. 94-469; 90 Stat. 2003; 15 U.S.C. 2601 et seq., hereinafter referred to as TSCA). The procedures for rulemaking under section 6 of TSCA (40 CFR Part 750), 42 FR 61269 (December 2, 1977), will be followed. The official record of rulemaking is located in Room 447, East Tower, Environmental Protection Agency, 401 M Street, SW, Washington, DC 20460, (202)-755-6956. It will be available for viewing and copying from 9 a.m. to 4 p.m., Monday through Friday, excluding holidays. Hearing transcripts and other hearing materials will be added to the record as they become available.

I. Chemical Waste Landfill Criteria

In Annex II of Subpart E of the PCB Rule (published elsewhere in today's **Federal Register**), the Agency specifies criteria for chemical waste landfills to be used for the disposal of PCBs. Section 761.41(b)(3), Hydrologic Conditions, states that the bottom of the landfill liner system or natural in-place soil barrier must be at least fifty feet from the historical high water table. This requirement is essentially the same as the provisions contained in § 761.41(b)(2), Hydrology, of the PCB Disposal and Marking Rule (43 FR 7150, 7161, February 17, 1978). The earlier version of the PCB Rules will be superseded in thirty days by the PCB Rule published in final form today.

Because the distance between the bottom of a chemical waste landfill and the historical high water table cannot be fifty feet or more in many areas east of the Mississippi River due to the closeness of the water table to the surface, EPA Regional Administrators have had to use the waiver provisions of § 761.41(c)(4) to waive this criterion in order to be able to approve PCB chemical waste landfills. The Regional Administrators have been able to grant these waivers because the shorter separation between the bottom of the landfill and the groundwater was found not to present an unreasonable risk of injury to health or the environment from PCBs. After examining the circumstances related to these waivers, EPA has concluded, for the reasons stated below, that the fifty foot criterion in the rule is too stringent, and that the rule should be modified accordingly.

The state of the art in the design and construction of chemical waste landfill liner systems and leachate detection and collection systems has advanced sufficiently so that the bottom of the liner system can be as close as five feet from the historical high water table. The liner systems are designed to be virtually impermeable, and the leachate collection systems are designed as a back-up measure to help insure that the liner system is not penetrated by liquids. This approach has also been included in the proposed EPA Hazardous Waste Guidelines and Regulations (40 CFR Part 250) [see 43 FR 58946-59028, December 18, 1978] in § 250.45-2(a)(2) proposed under the authority of the Resource Conservation and Recovery Act (RCRA).

This proposed change would modify § 761.41(b)(3), Hydrologic Conditions, of the PCB Rule, to change from fifty feet to five feet the required minimum distance between the bottom of the liner system and the historical high water table.

II. Effective Date

It is the intent of EPA to make the final version of this proposed amendment effective thirty days after the date of publication in the **Federal Register**. The final promulgation of this rule is expected in September 1979.

Dated: May 11, 1979.

Marilyn C. Bracken,

Acting Assistant Administrator for Toxic Substances.

Pursuant to the Toxic Substances Control Act, 15 U.S.C. 2605, and pursuant to authority delegated in the *Background* section of the Preamble to the Final PCB Regulation published elsewhere in today's **Federal Register**, the following amendment to 40 CFR Chapter I, Part 761 is proposed.

Subpart E—List of Annexes

Annex II

Section 761.41 is amended by revising subparagraph (b)(3) to read as follows:

§ 761.41 Chemical waste landfills.

* * * * *

(b) * * *

(3) *Hydrologic Conditions.* The bottom of the landfill liner system or natural in-place soil barrier shall be at least five feet above the historical high groundwater table. Floodplains, shorelands, and groundwater recharge areas shall be avoided. There shall be no hydraulic connection between the site and standing or flowing surface water. The site shall have monitoring wells and leachate collection.

[FR Doc. 79-16902 Filed 5-30-79; 8:45 am]

BILLING CODE 6560-01-M

APPENDIX B. ENVIRONMENTAL ASSESSMENT

PCB entry into the environment can occur by vaporation into the atmosphere (and by subsequent deposition into land and water) and by spilling or dumping into water or onto land. It has been established that of the 1970 sales of PCBs in North America, only 20% represented a net increase in the total amount in service. Estimated loss of PCBs for that year was 0.9 to 1.8 Gg by evaporation; 3.6 tl 4.5 Gg from leaks and disposal of fluids; and 20 Gg from disposal by incineration and burial (1). The cumulative input to the environment between 1930 and 1970 was estimated to be 27 Gg to air; 55 Gg to fresh and coastal waters; and 270 Gg to dumps and landfills. In that time, up to 1/3 of the PCBs released to air and 1/2 of those released to water were probably degraded (1). Degradation in landfills is more difficult to estimate.

B.1 SOURCES

Environmental contamination of the atmosphere from PCB losses has in the past occurred during:

- Disposal of PCBs, e.g., incomplete incineration and burning of PCB-containing wasted
- Accidental spills and leaks, e.g., spillage from PCB-containing products such as transformers
- Wear and weathering of PCB-containing products

The loss of PCBs as a consequence of incomplete incineration and burning of PCB-containing wastes has now been severely restricted and, where allowed, carefully monitored and regulated. The possibility of accidental release to the atmosphere from spills and leaks will, however, continue to pose a threat as long as PCBs exist, but, by the implementation of available control technology, it is possible to minimize PCB loss during transfer, storage, and disposal.

PCBs are transported either as a vapor or adsorbed onto particulates and are deposited on land or into bodies of water by particle fallout and precipitation. Most of the PCBs reaching the water are removed by particle scavenging, followed by sedimentation, and are only slowly released; small amounts remain dissolved and are subject to re-evaporation. Successive cycles of evaporation, adsorption, and deposition eventually carry the PCBs initially released on land to the coast and to their ultimate sink, the sediment of the Oceanic floor.

Nisbet and Sarofim (1) proposed a transport model which has help up reasonably well in the face of evidence, both experimental and analytical. It must be noted that they assumed PCBs to be similar in behavior to DDT. They predicted that PCBs are released directly to the atmosphere via evaporation from products, evaporation from themselves or incomplete incineration. The PCBs are carried through the air predominantly in the vapor phase or adsorbed onto particulates and may travel great distances in these forms. It is thought that the atmosphere provides the major route of transport for PCBs throughout the environment. PCBs are then deposited on land or into fresh and marine waters by particle sedimentation. The greatest loss to the atmosphere occurs in urban areas, and decreasing concentration gradients in air are observed from the coast out to the open ocean. Fallout onto land and water is also greatest in these areas, close to the sources of emission. Re-evaporation from the bodies of water and soil is a further source of atmospheric contamination. The extent of vaporization from the soil depends upon many factors, including the nature of the surface. Losses will be greatest from surfaces such as sand and small from soils with a high organic matter content. Evaporation and codistillation from the surface layer of bodies of water where PCBs accumulate in high lipid content surface microlayers may be significant. Shallow, fast-flowing rivers and streams where depleted surface layers are constantly renourished will experience the greatest loss of PCBs by this route.

Accidental spills and leaks and dumping of solid and liquid wastes are further sources of contamination of both water and soil. Although leaching from sanitary landfills is theoretically possible, evidence suggests that losses by this route are, in fact, negligible. Leaching from certain soil surfaces such as sand and creviced bedrock into groundwater supplies is, however, a more likely source of contamination. Contamination of soil by irrigation is also possible, especially if the water is taken from a contaminated source.

The fate of PCBs delivered to both fresh and marine waters is adsorption onto particulate matter and, ultimately, deposition into bottom sediment. Transport of PCBs in rivers to estuaries and the open sea takes place by solution and readsorption onto particulates and by the transport of sediment itself.

PCBs dissolved in relatively shallow water, in which there is close contact with bottom sediment, will adsorb onto the sediment rather than move to the surface layer and evaporate into the atmosphere. Only in deep waters does evaporation compete successfully with particulate scavenging and sedimentation.

B.2 MODELING

B.2.1 Air Pollution

To evaluate the impact of emissions, the relationship between atmospheric emissions and air quality must be established and the spatial distribution of atmospheric pollution in the vicinity of the pollution sources must be determined. One approach to determine this relationship is to assume that a change in emissions would cause a proportionate change in air quality. This approach, however, does not explicitly include the effects of meteorology, topography, and stack gas parameters and therefore does not insure an accurate estimate of the impact of emissions on the overall air quality. In response to this deficiency, the air quality "dispersion model" has become an accepted method for estimating the spatial distribution of pollutant concentrations.

Dispersion models simulate the effects of stack height, stack flow parameters, source distributions, and atmospheric elements, such as air flow and mixing, on the transport and dispersion of pollutants emitted into the atmosphere. Dispersion models are useful for calculating the spatial distribution of concentrations that result from various sources and can be manipulated to estimate ground-level concentrations for extreme meteogological conditions. If calibrated, the model can be used to predict concentrations for future expected emissions and meteorological situations. If uncalibrated, the model is useful for predicting the relative change in air quality as a result of varying emission parameters, meteorological conditions, and source distributions.

The U.S. Environmental Protection Agency (EPA) has developed several dispersion models which use the Gaussian diffusion equation. The basic formulation of the Gaussian equation assumes that the ground-level concentration is inversely proportional to the mean wind speed. The Gaussian distribution describes the horizontal and vertical pollutant dispersion in a plane normal to the wind direction.

In the prediction of the maximum concentration of pollutants such as PCBs it is common practice to model the "worst case" conditions that could occur as well as the most probable conditions. This worst case approach involves using not only the maximum pollutant concentration possible emitted but also assumes the pollutant will be dispersed under the meteorological conditions that are least favorable to its dilution. In this case the worst case would be of no PCB destruction at all during the combustion process, and the second and more probable condition would be that of 99.9% destruction of PCBs during combustion.

It is generally impossible to predict the exact meteorological conditions, but a very realistic estimate can be made based on historical data. It is also difficult to determine the exact atmospheric conditions of wind direction, wind speed, and stability that will result in the maximum concentration for a given source. However, for elevated sources, maximum concentrations generally occur near the source with unstable conditions. Under stable conditions, maximum concentrations occur some distance away from the source.

In some cases, the aerodynamic turbulence induced by a building can cause a pollutant emitted from an elevated source to be mixed rapidly toward the ground, resulting in higher ground level concentrations. This is particularly true when the source stack height does not meet Good Engineering Practice (GEP) criteria established by EPA. A simple rule of thumb may be applied to determine the source stack height which meets GEP requirements and is capable of avoiding downwash problems:

$$h_s \geq h_b + 1.5a$$

where h_b is the building height and "a" is the lesser of either building height or maximum building width. In other words, if the source stack height is equal to or greater than $h_b + 1.5a$, downwash is unlikely to be a problem. If there is more than one stack at a given facility, the above rule may be successfully applied to each stack.

A guide that recommends air quality modeling techniques with respect to 1) air quality models, 2) data bases, and 3) general requirements for concentration estimates is available from the EPA. This document is entitled "Guideline on Air Quality Models" and can be obtained from the Office of Air Quality Planning and Standards, Research Triangle Park, N.C.. For a better understanding of air pollution modeling it is recommended that this document be carefully studied.

B.2.2 Water Pollution

To evaluate the impact of PCB waste disposal by thermal destruction, the relationship between liquid wastes and the physical water environment must be established. In most cases, water pollution models are developed to determine dispersion patterns on a site specific basis. There is no guide available from the EPA or other sources that recommends water modeling techniques with respect to water quality models or data bases.

In general, a model is developed so that it can calculate the dilution effect of a water body such as a river or ocean on the effluent flow given a set of input conditions. The resulting dispersion patterns are examined, and conclusions and recommendations are made. In most cases it is preferred to verify these results with monitoring and sampling data.

Conceptually, models treat the liquid effluent as a plume emanating from what is effectively a point source. The plume is assumed to initially have some momentum and a density discontinuity with the ambient density. As soon as it is predicted to leave the discharge structure, entrainment of ambient fluid is assumed to begin, and the extent of this dilution is used to determine concentrations and temperatures within the plume. The essential purpose of the model is to calculate dilution factors for a number of points along the centerline of the plume so that actual physical parameters can be determined.

Mixing in the plume is achieved largely through shear forces acting on the walls of the plume initially generated by the relative momentum of the plume to the ambient fluid. After the plume loses momentum, ambient turbulence begins to play an important role. Plumes may reach the air-water interface if discharged close to the water surface. In such cases, the assumed geometry of the plume becomes semicircular and it acts as a surface jet.

B.2.3 Sampling and Analysis

PCB Regulations of thermal destruction of PCBs require the following stack gas constituents be monitored: O_2, CO, CO_2, NO_x, HCl, organic chlorides, PCBs, and total particulates. Continuous monitoring is required of O_2, CO, and CO_2. Other performance standards are stipulated regarding temperature, residence time, combustion efficiency, maximum allowable stack emission (when incinerating non-liquid PCB wastes), and automatic cutoff systems for below optimal conditions.

Although no specific requirement for ambient air monitoring under PCB regulation is listed, however, regulations to be established as a part of RCRA require not only monitoring of various incinerator parameters (e.g., temperature, concentrations of O_2, CO_2 and CO, etc.) but also monitoring of ambient air (at the facility's perimeter) and scrubber water.

Ambient air sampling for PCBs involves collection via filtration. The low concentrations of PCBs generally found in the ambient atmosphere require that a large volume of air be sampled. Three primary techniques are usually used for sampling of PCBs: liquid absorption methods, liquid phases on solid supports, and solid adsorbents. A description of the equipment required for these techniques and their application is discussed in Section 2. It is recommended that ambient air sampling be performed around the facility on a year round basis. Samplers should be placed so that they are either upwind or downwind from the incinerator or high efficiency boiler facility. If the wind direction shifts more than 30° from the original direction, samplers should be repositioned at reasonable time intervals.

Monitoring of the stack effluent, spent scrubber water, and solid combustion residue should also be performed. Stack concentrations of carbon monoxide, carbon dioxide and oxygen should be determined as specified in 40 CFR 60, EPA Method Number 3 (this method may not be sufficiently sensitive for CO). Stack concentration for hydrogen chloride should be determined by collecting the hydrogen chloride in an impinger filled with a caustic solution, such as dilute sodium hydroxide or sodium bicarbonate.

This solution should then be analyzed for chloride ion concentrations using the mercuric nitrate method. This method is described in Methods of Air Sampling and Analysis, 2nd Edition, and in Standard Methods for the Examination of Waste and Wastewater. Both are publications of the American Public Health Association.

Samples for analysis of total chlorinated organic content (which includes PCBs) should be collected on solid sorbent trap, such as XAD-2. Temperature control must be maintained since the absorptive characteristics of the trap change with temperature differences. The solid sorbent trap should be located in the sampling train downstream from the heated filter and upstream of the first impinger. After extraction, the sample can be analyzed for PCB content by gas chromatography-mass spectrometry.

Mass emission rates of total particulate matter should be determined in accordance with method specified in 40 CFR 60, Method 5.

Samples of the quench/scrubber water can be taken from several points depending upon the facility design. Listed in decreasing order of preference for obtaining a composite sample are: 1) a holding tank for ponds containing all the scrubber solution used during a burn, 2) recirculation tank for scrubber solutions being recycled, and 3) a pipe through which these scrubber solutions are being pumped. The advantage of collecting a sample from holding tanks or ponds is that it is a composite sample and, as such, can be obtained without the requirement for collecting frequent grab samples or using automated sampling equipment.

The solid residues remaining after combustion of the wastes should also be sampled. Samples can be taken from the accumulated residue after each run.

A compendium of sampling methods and analytical procedures which may be referred to and used by the PCB disposal facility owner/operators to assist them with any sampling and analytical testing required under 40 CFR Part 761, Polychlorinated Biphenyls, is provided in an EPA interim report published in February 1978 entitled "Sampling Methods and Analytical Procedures Manual for PCB Disposal: Interim Report". Copies of this document can be obtained from the Industry Assistance Office, Office of Toxic Substances, Washington, D.C. Toll free numbers are: Toxic Substances, (800)-424-9065 and Hazardous Waste, (800)-336-4563.

B.3 CONTROL METHODS

During transportation of PCBs and PCB-contaminated materials to disposal facilities, accidental spillage or leakage can occur. To control surface transportation of hazardous materials, the Department of Transportation published Code of Title 49, Federal Regulations (CFR), Parts 170-178. For air transport, more specific controls were deemed necessary and the Federal Aviation Regulations (FAR), Vol. VI, Part 103 were drafted to modify 49 CFR. In some cases the more restricted procedures proposed by airlines in their airline tariffs to the Civil Aeronautics Board (CAB) are applicable. All the regulations are designed to prevent spills from occurring and to protect life and property. An EPA document entitled "Manual for the Control of Hazardous Material Spills: Volume 1 - Spill Assessment and Water Treatment Techniques" lists information regarding all the activities that are necessary. Spill prevention procedures have also been listed in the PCB Regulations (Annex III-3). EPA has also proposed a spill prevention rule for hazardous substances (including PCBs) under Section 311 of the Clean Water Act (43 FR 39276, September 1, 1978). When this spill prevention rule is promulgated, the spill prevention provision of the PCB rule will be revised.

However, if spills do occur and a good faith attempt is not made to clean up the spill, then this constitutes improper disposal of PCBs and is a violation of the Toxic Substances Control Act. Violations of this sort can result in civil and criminal penalties. Federal regulations require that non-liquid PCB-contaminated materials such as rags and sorbent materials (e.g., sawdust or imbiber beads that have been used to absorb spilled fluids) be packed in drums before shipment to appropriate landfills. Liquid wastes including cleanup solvents such as kerosene and fuel oil must be packed in steel drums of appropriate wall thickness and then must be put into secured storage areas until disposal can be arranged. It is recommended that protective clothing be used by the personnel during the cleanup operation. While it is unlikely that high temperature PCBs will be encountered during cleanup, it is advisable that personnel use some kind of self-contained breathing apparatus because PCB fumes can be easily inhaled during this process. A comprehensive inventory of protective clothing is available in the U.S. Government Printing Office publication "A Survey of Personnel Protective Equipment and Respiratory Apparatus for Use by Coast Guard Personnel in Response to Discharge of Hazardous Chemicals".

If a spill drains into the soil then it is required that many tons of the soil be excavated and transported to chemical landfills. Complete removal of PCBs in this manner may, however, never be achieved.

Storage areas at commercial incinerators are also needed for temporary storage of fluids and contaminated materials prior to incineration. Storage facilities at disposal plants are required to comply with Federal Regulations. These requirements are listed in Annex III-5 of the PCB Regulations (40 CFR Part 761).

B.3.1 Air Pollution Control

If one assumes that commercial incinerators and high efficiency boilers operate properly, then these units will achieve greater than 99.9% destruction and will not be sources of PCB contamination of the atmosphere. However, previous studies have indicated (2) that fly ash and residue fines contain PCBs.

Control devices have been found to effectively remove complete and incomplete combustion products prior to venting from the stacks. These include cyclones, venturi scrubbers, high energy scrubbers, electrostatic precipitators and fabric filters. Charged droplet scrubbers can also be used to remove fine particulates in the micron and submicron size range. In most incinerators, however, the only scrubbing that occurs is when exit gas containing fly ash passes into a baffle system that has water running down the wall.

PCB vapor removal from the emissions is performed by alkaline scrubbing at pH 11 to pH 12. Packed-bed scrubbers are also effective in eliminating vapors.

A by-product of scrubbing is PCB contaminated absorbent liquid. The absorbent liquid includes PCBs associated with the particulates that dissolve in the liquid while the particles are settling in the clarifier as well as the PCB vapor that is scrubbed.

B.3.2 Water and Solid Waste Pollution Control

Residues and fly ash from incinerators or high efficiency boilers, and sludge and absorbent liquid from the scrubbers which contain PCBs are usually deposited in landfills. These materials are packed in proper containers (refer to 40 CFR Part 761 Annex III for container specifications under PCB Regulations) to prevent leaks and spills and also the leaching of PCBs. In addition, any hardware which contained PCBs should be drained and then washed with solvents to remove all traces of PCBs prior to disposal by burial or recycling of metal.

When burial is the method of disposal, a Class I landfill site is usually used. Such a site may accept any type of waste including toxic and hazardous materials because the fill will not enter the groundwater. Class I landfill sites are located in special geologic areas or in special structures such as deep wells or empty missile silos. A list of EPA approved chemical waste landfills can be obtained from the November 21, 1979 issue of the Federal Register.

Properly designed and operated chemical waste landfills are capable of containing liquid wastes when the liquids are stabilized in the disposal process or contained in cells of sorbent material as required by PCB Regulations, 40 CFR Part 761. EPA's Office of Solid Waste recommends mixing liquids with soils or solid wastes in order to stabilize liquid wastes. In addition, containers of the liquids should be surrounded by inert sorbent material to absorb all of the liquid contained in the container if it should leak. These techniques have been found to effectively control the migration of PCBs from the landfill site. Use of such landfills results in only limited exposures to PCBs. Almost all of the exposure occurs during the liquid stabilization process. Such use of chemical waste landfills is consistent with hazardous waste disposal policies being proposed by EPA under RCRA (43 FR 58946).

PCBs can enter the soil by runoff of rainwater and from improper disposal of PCBs and PCB-contaminated materials. Leaching has also caused the transfer of PCBs from water to soil. Another source of soil contamination is the absorbent liquid from scrubbers.

Carbon adsorption units have been used for the removal of PCBs from aqueous effluent (up to 500 ppt). However, complete removal can seldom be achieved. Again, the most common method of disposal of solid waste is burial in approved chemical waste landfills. EPA has decided to permit the disposal of non-liquid PCBs at any concentration in chemical waste landfills that meet the requirements of 40 CFR Part 761 Annex II.

REFERENCES

1. Nisbet, C.T. and A.F. Sarofim, "Rates and Routes of Transport of PCBs in the Environment," Environ. Health. Perspect., 1,21 (1972).

2. "Destroying Chemical Wastes in Commercial Scale Incinerators Facility Report #6," by TRW Inc. for U.S. EPA, Contract No. 68-01-2966, June 1977.

APPENDIX C. SAMPLE CALCULATIONS

C.1 COMBUSTION EFFICIENCY CALCULATION

Combustion efficiency is defined as % CE = 100 x % CO_2/% CO_2 + % CO where % CO_2 is the percentage CO_2 composition of the combustion effluent, and % CO is the percentage CO composition of the combustion effluent.

Assume that CO_2 is 9% of the combustion effluent and CO is 9 parts per million (ppm) or 0.0009%.

Therefore, combustion efficiency is

$$\%\ CE = \frac{\%\ CO_2}{\%\ CO_2 + \%\ CO} \times 100 = \frac{9}{9 + 0.0009} \times 100 = 99.99\%$$

C.2 RESIDENCE TIME CALCULATION

Residence or dwell time is usually calculated as follows.

$$t = \frac{V}{Q\ (T/Tstd)}$$

where:

t = residence time (sec)
V = volume of furnace chamber (m^3)
Q = volumetric flow rate (m^3/sec) at standard temperature and pressure
T = combustion temperature (°K), and
T_{std} = standard temperature (°K)

Because the furnace chamber volume is generally larger than the volume in which the gases are at the required temperature, this method of calculation produces an upper bound estimate. The true volume can only be determined by sophisticated tracer studies.

Assume an incinerator unit has a furnace volume of 120 m^3 and an air supply of 90,000 m^3/hr at normal temperature and pressure. Therefore, for a furnace combustion chamber temperature of 1200°C the residence time will be:

$t = \frac{V}{Q} = 120/(90{,}000/3600)(1473/293) = 0.95$ seconds

C.3 DESTRUCTION EFFICIENCY CALCULATION

Destruction efficiency is defined as

$$\% \text{ DE} = 100 \left[\frac{Q_{in} - Q_{out}}{Q_{in}}\right]$$

where:

Q_{in} = amount of PCBs into the incinerator or high efficiency boiler (m^3/sec or kg/hr)

Q_{out} = amount of PCBs exiting the incinerator or high efficiency boiler (m^3/sec or kg/hr)

Assume that 1015 g/min of PCBs are input into an incinerator, the flue gases contain 0.005 mg/m^3 of PCBs, the scrubber effluent contains undetectable amounts of PCBs, and the flow rate of the flue gas is 630 dry standard cubic meter per minute. Therefore, the destruction efficiency is:

$$\% \text{ DE} = 100 \left[\frac{Q_{in} - Q_{out}}{Q_{in}}\right]$$

$$= 100 \times ((1015 \text{ g.min}^{-1} - 630 \text{ m}^3\text{.min}^{-1} \times 0.005 \text{ mg.m}^{-3} \times 10^{-3} \text{ g.mg}^{-1}) /1015 \text{ g.min}^{-1}) = 99.99\%$$